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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 93. 6456

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M 93

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Vice-Principal: E. M. WRONG, M. A. (Fellow Magdalen Coll., Oxford).

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The University of Sheffield.

SESSION 1918-19.

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Applications should be made on a form obtainable at these Offices, and should be returned to me by July 31st.
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July, 1918. M 138

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Application to be made by Friday, the 26th instant, on a form to be obtained from the Secretary of the Department.
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Manager for Moderate Sized
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WANTED, Male (ineligible) or female. Experience in mechanical purchasing essential.—Apply in writing, stating age, salary required, and giving full particulars of experience to M 164, Offices of ENGINEERING.

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M 99

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forced Concrete Ships. Good knowledge of Ferro-concrete design essential. No person at present engaged on Government work need apply.—Apply, giving full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 124.

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REQUIRED. The above positions are permanent to reliable individuals. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4985. L 646

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Designing Engineer for
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Draughtsmen Required for
temporary service in an Admiralty Department, a knowledge of Marine Engineering being essential. Salary up to £6 a week, inclusive of war bonus with overtime in addition, according to qualifications.—Applicants to state age and details of experience, to reach BOX No. 1075, WILLINGS, 125, Strand, London, W.C. 2, not later than July 31st. L 877

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TAKE CHARGE of Coal Washery Department. Experienced men only need apply.—Full particulars in the first place to K 634, Offices of ENGINEERING.

Draughtsmen Wanted, for
Engineering Works Plant and Equipment. Only men with good practical shop experience and sound theoretical training need apply. No person already on Government work will be engaged.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 5636. M 23

Draughtsman Wanted at once
for general Engineering. State salary required, experience and age, or apply personally to SIMON, 21, Panton Street, Haymarket. M 117

Wanted a Draughtsman, in
or near London to draw Plan of Patent Rotary Engine in spare time.—Address, M 133, Offices of ENGINEERING.

Mechanical Draughtsmen
REQUIRED, with a sound, practical knowledge of engine, chassis and gear box design for cars, lorries, and caterpillar tractors—petrol and steam driven. No person already on Government work will be engaged.—Apply, giving details of experience, stating age, salary required, and forwarding copies of recent testimonials, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5712. M 111

A NEW THEORY OF THE STEAM TURBINE.

By HAROLD MEDWAY MARTIN, Wh.Sc., A.C.G.I.

(*Continued from page* 3.)

It has long been a commonplace of steam turbine practice that the gain made by the use of superheated in place of saturated steam is substantially more than is thermo-dynamically due. Mr. Baumann, for example, in the very valuable paper he read before the Institution of Electrical Engineers in 1912, has given curves showing the changes in the steam consumption per kilowatt-hour when a turbine designed to work normally with steam supplied at a stop-valve pressure of 180 lb. gauge pressure and 150 deg. superheat, the exhaust pressure being about 1 lb. absolute, is operated with unchanged pressures but with higher or lower degrees of superheat. This curve is reproduced in Fig. 1.

Last year an extended set of correction tables were issued under the auspices of the British Electrical and Allied Manufacturers' Association. These were drawn up by Mr. C. H. Naylor, with Mr. Baumann's assistance, and from these figures, combined with the heat-drop tables compiled by Mr. Moss, M.Sc., on behalf of the same association, we get the following figures of relative consumptions under Mr. Baumann's standard conditions :—

Superheat dg. F.	0	50	100	150	200	250	300
Relative consumption	1.160	1.101	1.046	1.000	0.9592	0.9235	0.8909

Comparing these figures with the curve it would seem that the saving due to a superheat of 150 deg. F. is now reckoned at 16 per cent. instead of at 15 per cent., as in 1912. This may be due to the improvements effected during the past eight years in average turbine efficiencies, since, as will be shown later on, theory indicates that, with any given type of turbine, the relative gain should increase somewhat with the efficiency of the turbine. This is the reverse of the opinion generally held.

In most questions relating to turbine theory it is convenient to take, for purposes of comparison, the condition of the steam not as supplied at the stop valve, but after passing through the governor valve. Generally there is, with high-pressure turbines, a drop of pressure here of about one atmosphere, this being necessary to secure satisfactory governing, in face of the inevitable fluctuations in the boiler pressure. If Mr. Baumann's curve be reduced correspondingly we get the percentage gains and losses shown in the annexed table.

TABLE I.—*Superheat Corrections for Steam Turbines when the Absolute Pressure below the Governor Valve is* 180 *lb. per square inch and the Absolute Exhaust Pressure* 1 *lb. per square inch.*

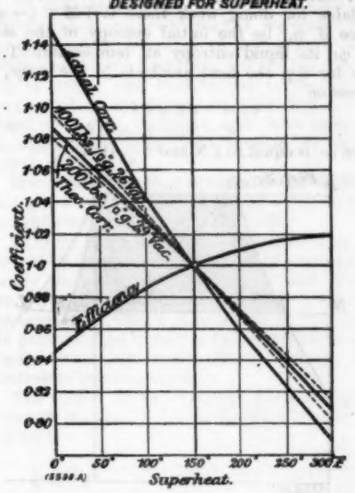
Superheat below governor valve, deg. F.	0	50	100	150	200	250	300
Relative steam consumption	116.3	110.5	104.6	100.0	95.9	92.4	89.1
Adiabatic available heat (Callendar), B.Th.U.	331.3	341.3	351.9	363.1	374.8	387.0	399.6
Calculated relative consumption if proportional to adiabatic heat drop ..	109.6	106.3	103.2	100.0	94.2	93.8	90.9

Actually the discrepancies between the figures are somewhat larger than the above table indicates, since the ratio of blade speed to steam speed will be, on the average, less the greater the amount of available heat. When this factor is taken into account the discrepancy is increased by another 2 per cent. or 3 per cent.

As a matter of fact, moreover, the heat which becomes available in a steam turbine differs from the adiabatic heat drop, and is, in general, considerably larger. The ratio of the two is known as the reheat factor, and this reheat factor is, as will be shown, substantially greater for superheated than for saturated steam, when the latter is assumed to be in thermal equilibrium throughout the whole of its expansion.

Suppose a turbine to consist of an infinite number of stages. At each stage a certain portion of the total energy of the steam is converted into kinetic energy, of which a part is expended in doing useful work on the shaft, and the remainder, which is wasted in friction, is restored to the expanding steam in the form of heat; the consequence is that at each stage the pressure corresponding to a given volume of the steam is somewhat greater than it would be did the turbine work friction free. Whether steam be used to actuate a turbine or a reciprocating engine the amount of work done down to any stage of the expansion can be represented by an ideal indicator diagram such as is shown in Fig. 2. In this the expansion line B D is that corresponding to frictionless working or to unit efficiency, whilst B E represents the expansion line for a turbine working with an hydraulic efficiency η. The total area of the diagram is in this case larger than before, because the energy wasted in friction, being returned to the steam as heat, makes the volume at every point of the stroke more than if unit efficiency were attained. Of this larger diagram, however, only the fraction η is recovered as useful work on the shaft, whereas in the ideal case of unit efficiency

Fig. 1. SUPERHEAT CORRECTIONS FOR LOW-PRESSURE TURBINE DESIGNED FOR SUPERHEAT.



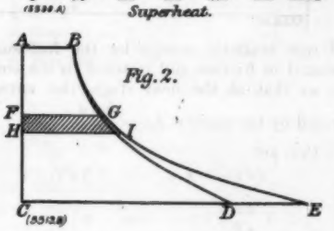


Fig. 2.

the useful work done is represented by the whole of the area A B D C. In all cases $\eta \times$ A B E C is less than A B D C.

The efficiency ratio ϵ of the turbine is equal to the actual work done divided by that theoretically due from a perfect turbine, or

$$\epsilon = \eta \frac{\text{ABEC}}{\text{ABDC}}$$

and the reheat factor R is defined by the relation

$$\text{R} = \frac{\text{ABEC}}{\text{ABDC}}$$

so that $\epsilon = \eta$ R, where η is known as the hydraulic efficiency of the turbine.

The actual thermo-dynamic head under which any turbine works is, therefore, not represented by the adiabatic heat drop u, but by a larger quantity U, where $\text{U} = \text{R}\,u$.

The value of R corresponding to different values of η can be determined in the following way :—

If a quantity of heat be added to a fluid, the latter will, in general, both increase in temperature and expand in volume. By the first law of thermo-dynamics we have :

Heat added = change of internal energy + external work done.

Taking all quantities in ft.-lb. units, this may be expressed algebraically by the relation

$$dq = dE + P\,dV \quad . \quad . \quad . \quad (1)$$

where dq denotes the quantity of heat added to 1lb of the working substance, dE the corresponding change of internal energy, and $P\,dV$ the external work done by the corresponding change of volume.

In the first place, consider a change to take place adiabatically; that is to say, the fluid expands without the addition or loss of energy in the form of heat. In that case $dq = 0$, and we have the relation :

$$dE = -P\,dV \quad . \quad . \quad . \quad . \quad (2)$$

Now it is known from experiment that when superheated steam expands adiabatically the law of expansion is given with substantial accuracy by the relation $P\,V^{\gamma} = C$* where C is a constant. Substituting for P and integrating we get for the internal energy E, the value

$$E = \frac{PV}{\gamma - 1}$$

No constant of integration is required, as $E = 0$ when $P = 0$. If, then, we substitute this value for E in (1) we get

$$dq = \frac{1}{\gamma - 1} d(PV) + P\,dV \quad . \quad . \quad (3)$$

Suppose that at each stage of our imaginary turbine the fraction k of the corresponding area of the indicator diagram is wasted in friction and returned to the steam as heat. That is to say, if F G I H, Fig. 2, denote the diagram for this stage, we have

$$dq = k \times \text{FGIH} = -k\,V\,dP$$

the negative sign being required because the work done increases as the pressure falls.

We thus get from (3)

$$-k\,V\,dP = \frac{1}{\gamma - 1}(V\,dP + P\,dV) + P\,dV$$

or

$$-\left(k + \frac{1}{\gamma - 1}\right) V\,dP = \left(1 + \frac{1}{\gamma - 1}\right) P\,dV$$

therefore

$$\left(1 + \frac{1}{\gamma - 1}\right)\frac{dV}{V} + \left(k + \frac{1}{\gamma - 1}\right)\frac{dP}{P} = 0$$

The integral of which is obviously

$$P\,V^{\frac{1 + \frac{1}{\gamma - 1}}{\frac{1}{\gamma - 1} + k}} = \text{constant.}$$

If we put

$$\lambda = \frac{1 + \frac{1}{\gamma - 1}}{\frac{1}{\gamma - 1} + k}$$

and remember that $k = 1 - \eta$, where η is the hydraulic efficiency, we get

$$\lambda = \frac{\frac{1}{\gamma - 1} + 1}{\frac{1}{\gamma - 1} + 1 - \eta}$$

Hence

$$\lambda - 1 = \frac{\eta}{\frac{1}{\gamma - 1} + 1 - \eta}$$

so that

$$\frac{\lambda - 1}{\lambda} = \eta\,\frac{\gamma - 1}{\gamma} \quad . \quad . \quad . \quad (4)$$

where γ denotes, of course, the index when the expansion is adiabatic.

For purposes of calculation (4) is more conveniently, if less symmetrically, expressed as

$$\frac{1}{\lambda} = 1 - \eta\left(1 - \frac{1}{\gamma}\right)$$

For superheated steam the value of γ is 1.3, so that in this case

$$\frac{1}{\lambda} = 1 - 0.23077\,\eta.$$

In the foregoing P denotes, of course, the pressure of the gas or vapour in pounds per sq. ft., whilst in practice it is more convenient to work with pressures expressed in lb. per sq. in. Denoting this by p, then if the law of expansion be $p\,V^{\lambda} =$ constant, the area of the corresponding indicator diagram is

$$\frac{144}{1 - \frac{1}{\lambda}}\, p_0 V_0 \left(1 - \left(\frac{1}{x}\right)^{1 - \frac{1}{\lambda}}\right)$$

where x denotes the ratio of the initial to the final pressure.

* According to Callendar a more precise expression is $p\,(V - b)^{1.3} =$ constant where $b = 0.01602$.

Hence the reheat factor corresponding to an hydraulic efficiency η is given by the relation

$$R = \frac{1-\frac{1}{\gamma}}{1-\frac{1}{\lambda}} \cdot \frac{1-\left(\frac{1}{x}\right)^{1-\frac{1}{\lambda}}}{1-\left(\frac{1}{x}\right)^{1-\frac{1}{\gamma}}}$$

But

$$1-\frac{1}{\lambda} = \eta\left(1-\frac{1}{\gamma}\right)$$

Thus, finally

$$R = \frac{1}{\eta} \cdot \frac{1-\left(\frac{1}{x}\right)^{\eta\left(1-\frac{1}{\gamma}\right)}}{1-\left(\frac{1}{x}\right)^{1-\frac{1}{\gamma}}}$$

In the case of superheated steam $\gamma = 1.3$, and on this basis the following values of the reheat factor for different hydraulic efficiencies have been calculated :—

TABLE II.—*Reheat Factor for Steam Superheated throughout the Whole Range of its Expansion.*

Values of $x = \frac{p_0}{p_1}$	Hydraulic Efficiency η =			
	0.5.	0.6.	0.7.	0.8.
1	1.0000	1.0000	1.0000	1.0000
2	1.0393	1.0312	1.0235	1.0160
4	1.0753	1.0629	1.0468	1.0310
6	1.1033	1.0809	1.0602	1.0397
8	1.1195	1.0934	1.0695	1.0454
10	1.1310	1.1024	1.0762	1.0494
15	1.1554	1.1209	1.0891	1.0585
20	1.1691	1.1313	1.0964	1.0617
25	1.1841	1.1445	1.1057	1.0692
50	1.2219	1.1718	1.1253	1.0810
100	1.2586	1.1998	1.1450	1.0932
200	1.2962	1.2279	1.1643	1.1053

The above values for the reheat factor would not be sensibly altered if we had used the more exact expressions for the adiabatic expansion of superheated steam, viz.,

$$(V-b)^{1\cdot3}\, p = \text{constant}.$$

In this case the work done in the expansion becomes

$$144\left[\frac{\lambda}{1-\lambda}\left(V_0-\frac{\lambda}{\gamma}b\right)\left(1-\left(\frac{1}{x}\right)^{\frac{\lambda-1}{\lambda}}\right)+\frac{\lambda}{\gamma}b(p_0-p_1)\right],$$

where λ and γ have the same values as before and $b = 0.01602$.

A somewhat curious paradox follows from the expression found above for the reheat factor R, viz. :—If the expansion be carried far enough the efficiency ratio is independent of the hydraulic efficiency.—Thus making $x = \infty$ we get $R = \frac{1}{\eta}$, and since the efficiency ratio e is equal to $R\,\eta$, its value is always unity if the expansion be carried to zero pressure. The physical explanation of this result is simple. To reduce the final pressure to zero we must go down to the absolute zero of temperature. In deducing the value of R it was assumed that all the heat energy not expended in doing useful work was restored to the fluid in the form of heat. At the absolute zero of temperature the working fluid retains no heat energy, and the latter has accordingly all been turned into useful work and the efficiency ratio is unity, however great the frictional losses may have been at each stage of the turbine.

The curves of reheat factors already published on Plate I, published with our issue of the 5th inst., have been plotted by extending the above table.

For the adiabatic expansion of wet or saturated steam in thermal equilibrium an expression of the form $p\,V^{\gamma} =$ constant is only moderately accurate, and the error is aggravated in reheat factors deduced in the foregoing fashion. The reheat factor for such cases can, however, be obtained accurately in another way, as shown in an article entitled "The Compound Steam Turbine," which appeared in ENGINEERING, vol. LXXIX, page 37. For convenience of reference we repeat the argument here.

Referring to Fig. 3, which represents the temperature-entropy diagram for steam, C L being the saturation line, then if the expansion took place adiabatically from the condition represented by C, the heat available between the temperature corresponding to the line A C and that corresponding to the line N L is represented by the area I B C H. If, however, the expansion takes place with less than unit efficiency, the heat generated by the friction is restored to the steam, and at every point the steam is, therefore, drier than it otherwise would be, and the entropy is correspondingly greater. Hence at each stage the amount of heat available for further work in the turbine is more than if the expansion took place adiabatically, though, of course, less of this available heat is converted into useful work on the shaft. The heat which becomes available in such case is equal to the whole hatched area I B C M, and the reheat factor is equal to $1 + \frac{\text{area H C M}}{\text{area I B C H}}$.

If z denote the horizontal distance at any point between the line C H and the curve C M, its value can be found in the following way. Let the point M, Fig. 3, represent the condition of the steam in a stage, having the absolute temperature T, of a turbine with an infinite number of stages. If the drop of temperature to the next stage be $d\,T$, then, having regard to the sign of T, the heat available for doing work there is $I\,M \times (-d\,T)$. Hence if ϕ_1 be the initial entropy of the steam and ϕ_l its liquid entropy at temperature T, we have for $d\,q$, the heat available in the stage, the expression

$$d\,q = -\,I\,M \times d\,T$$
$$= -\,(\phi_1 - \phi_l + Z)\,d\,T$$

where ϕ_l is equal to I N and $z =$ H M.

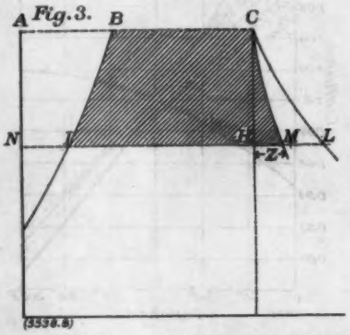


Fig. 3.

(3558.8)

Of this available energy let the fraction $k\,d\,q$ be wasted in friction and restored to the steam as heat, so that at the next stage the entropy is increased by the amount $d\,z = \frac{k\,d\,q}{T}$

We thus get

$$T\,d\,z = -\,k\,(\phi_1 - \phi_l + z)\,d\,T,$$

or :

$$T\,\frac{d\,z}{d\,T} + k\,z = -\,k\,(\phi_1 - \phi_l)$$

Multiplying by T^{k-1}, this gives

$$T^k\,\frac{d\,z}{d\,T} + k\,z\,T^{k-1} = -\,k\,(\phi_1 - \phi_l)\,T^{k-1}$$

i.e.,

$$\frac{d}{d\,T}\cdot\left(z\,T^k\right) = -\,k\,(\phi_1 - \phi_l)\,T^{k-1},$$

or :

$$z\,T^k = A - \phi_1\,T^k + k\int \phi_l\,T^{k-1}\,d\,T. \quad . \quad (7)$$

Here A denotes the constant of integration determined by the relation $z = 0$ when $T = T_1$.

In the article already cited it was pointed out that for the range of pressures usual in practice the liquid entropy can be represented very satisfactorily by an expression of the form

$$\phi_l = a\,T^{\frac{1}{10}} - b \quad . \quad . \quad . \quad (8)$$

where T denotes the absolute temperature.

If we adopt Callendar's steam table as our standard the value of a is 5.6054 for Centigrade units, or 5.2855 for Fahrenheit units, the value of b in both cases being 9.8221. The degree of accuracy of the formula is indicated by the following comparative figures, all taken to four digits :—

Temperature deg. C. ..	30	60	90	120	150	180	210
Abs. pressure lb. per sq. in.	0.6102	2.887	10.161	28.81	69.15	145.6	275.8
ϕ_l by Formula ..	0.1038	0.1980	0.2846	0.3652	0.4403	0.5110	0.5771
ϕ_l (Callendar's table)	0.1039	0.1982	0.2845	0.3646	0.4396	0.5108	0.5790

For the range covered in this comparison the formula is thus about as accurate as the available experimental results, and can be safely adopted for evaluating the integral in (7). This gives :

$$z = \frac{A}{T^k} - (\phi_1 + b) + \frac{10k}{10k+1}\cdot a\,T^{\frac{1}{10}} \quad . \quad . \quad (8)$$

The area C H M (Fig. 3) is, of course

$$-\int_1^2 z\,d\,T = \frac{A}{1-k}\cdot\left(T_1^{1-k} - T_2^{1-k}\right) - (\phi_1 + b)\,(T_2 - T_1) + \frac{10k}{10k+1}\cdot\frac{a\,T^{1\cdot1}}{1\cdot1}\Big]_2^1 \quad . \quad . \quad . \quad (9)$$

Both of the above expressions, (8) and (9), can be thrown into an apparently simpler form by use of the relation $a\,T^{\frac{1}{10}} = \phi_l + b$.

If we denote the above integral by $\Delta\,u$, whilst u represents the heat available in adiabatic expansion, the reheat factor is given by

$$R = 1 + \frac{\Delta u}{u}.$$

The following table gives the value of R for steam initially dry, expanding in thermal equilibrium throughout; that is to say, with no undercooling. As pointed out in our introductory article, this condition is not realised in turbine practice, or, indeed, in reciprocating engine practice either.

TABLE III.—*Reheat Factors* R *for Steam initially in the Dry but Saturated Condition, and Expanded from Different Initial Pressures down to* 1 *lb. Absolute, Thermal Equilibrium being maintained throughout the Expansion.*

Abs. Initial Pressure, lb. per sq. in.	Abs. Final Pressure, lb. per sq. in.	Hydraulic Efficiency.				
		0.5.	0.6.	0.7.	0.8.	0.9.
2	1	1.0085	1.0078	1.0065	1.0046	1.0022
4	1	1.0191	1.0163	1.0129	1.0089	1.0043
6	1	1.0284	1.0217	1.0169	1.0114	1.0056
8	1	1.0316	1.0256	1.0195	1.0130	1.0062
10	1	1.0355	1.0290	1.0221	1.0148	1.0061
15	1	1.0435	1.0348	1.0264	1.0181	1.0078
20	1	1.0496	1.0394	1.0294	1.0191	1.0088
25	1	1.0537	1.0427	1.0318	1.0210	1.0104
50	1	1.0669	1.0531	1.0394	1.0261	1.0129
100	1	1.0809	1.0640	1.0475	1.0313	1.0155
200	1	1.0956	1.0755	1.0559	1.0368	1.0162

$$R = 1 + \frac{\int z\,d\,T}{u} \text{ : where } z = \frac{A}{T^k} - \left[-\phi + \frac{k}{T^k}\int T^{k-1}\,\phi_l\,d\,T.\right.$$

u = Adiabatic Heat Drop.
T = Absolute Temperature.
ϕ = Initial Total Entropy.
ϕ_l = Liquid Entropy at T deg.

Seven-figure logarithms have been used in calculating the above table, since the quantity sought is expressed in equation (9) as the difference of two nearly equal quantities.

A comparison of Tables II and III is instructive. Suppose a steam turbine designed to give an hydraulic efficiency of 0.7 for the range of expansion of from 200 lb. absolute down to 1 lb. absolute. Then if the steam supply is saturated and the expansion takes place in thermal equilibrium throughout, its thermodynamic efficiency ratio will, from Table III, be $0.7 \times 1.0559 = 0.739$ nearly. If, on the other hand, the turbine is designed to give the same hydraulic efficiency with steam supplied at 200 lb., and superheated to such an extent that the superheat is not lost when the exhaust port is reached, the efficiency ratio will be $0.7 \times 1.1643 = 0.815$ nearly. Hence, with the same hydraulic efficiency the thermo-dynamic efficiency ratio will be fully 10 per cent. more with superheated than with saturated steam expanding in thermal equilibrium.

It will be obvious, therefore, that the adiabatic heat drop forms a somewhat fallacious foundation for estimating the saving to be effected by superheating the steam.

Carnot's theorem that the efficiency of a reversible engine depends solely on the initial and final temperatures, and is independent of the nature of the working agent, must not, in short, be extended to cover actual turbines, in which the efficiency ratio is always less than unity. The physical reason for this lies in the fact that whilst with such gases as argon, helium, or as superheated mercury vapour, which have spherical molecules, the whole of any heat energy added goes to increase the energy of translation of the molecules, in diatomic gases two-fifths of the heat energy supplied will be utilised in

increasing the rate at which the molecules spin. Hence only three-fifths of the heat energy added will be available for increasing the translational kinetic energy of the molecules, to which the pressure developed is directly proportional. Hence of two turbines of the same hydraulic efficiency one working with mercury vapour and the second with steam, the mercury turbine will have the higher efficiency ratio. In the case of wet steam much of any heat added goes in promoting evaporation of the water particles, and hence a comparatively small proportion is available for increasing or maintaining the pressure. The latter rises, accordingly, relatively little above the value it would have at the same specific volume were the expansion adiabatic.

(To be continued.)

COAL SAVING BY THE SCIENTIFIC CONTROL OF STEAM BOILER PLANTS.

By D. BROWNLIE, B.Sc.Hons. (Lond.), F.C.S.

(Concluded from page 27.)

(L) *Economisers.*—Out of the 250 plants tested, 155 plants were fitted with economisers, the other 95 plants having no means of utilising the waste heat from the boiler flues.

In several of these latter cases the economisers had been worn out and never replaced. In the figure for the average of 250 tests, the saving due to the economisers is 7·1 per cent., which includes, of course, 95 plants not fitted with economisers.

Taking the 155 plants fitted with economisers, the average saving is 11·4 per cent. of the coal bill. The highest figure found was 19 per cent. on a cotton-mill plant. The correct figure obtained on a well-managed plant is 15 per cent. to 20 per cent. saving, depending on the conditions.

The makers of economisers generally state that 15 per cent. to 25 per cent. of the coal can be saved, by installing economisers, meaning, it is presumed, after the boiler has received its proper proportion of heat and the efficiency of the boiler only is as high as it should be. It is naturally quite easy to increase the "saving" due to the economisers, for example, by running an induced-draught fan at high speed and reducing the efficiency of the boilers.

It is often found that plants showing over 17½ per cent. saving due to the economisers are caused in this way, and the figure in such a case is therefore not a real saving in the scientific sense of the word. Whether it is possible to get 25 per cent. real saving is a matter of opinion. In almost every case economisers are installed in the most rule-of-thumb manner, the general practice being to allow 72 or 96 tubes for each boiler, quite regardless of the evaporation of the boilers. The economiser makers generally recommend sufficient tubes to hold about an hour's supply of feed water, reckoning the capacity of each 9-ft. tube as 6½ gallons.

When it is remembered that a 30-ft. by 8-ft. "Lancashire" boiler may be evaporating on an average anything from 300 gallons to 1,000 gallons per hour, and economisers are almost always installed without knowing anything of the evaporation of the plant, it will be obvious that economisers do not get a fair chance to show maximum efficiency. Also in a large number of cases they receive practically no attention, are allowed to "scale-up" inside, and in some cases even the scrapers are not working.

(M) *Method of Draught.*—Out of the 250 plants, 123 were working with chimney draught only, 93 with some form of steam-jet apparatus to assist the chimney draught, 32 with mechanical induced-draught fan, and 2 with mechanical forced-draught fan.

The draught obtained in 123 cases by means of chimney only was found to average 0·70 in. suction-water gauge in the chimney base, giving 0·35 in. suction-water gauge in the side flues of the boiler. The highest water gauge observed was 1·6 in. in the chimney base. As regards temperature in the chimney base, the average for the 123 cases was 456 deg. F., varying from the lowest at 293 deg. F., to the highest 920 deg. F.

Comparing the 123 cases of chimney draught with the 32 cases of mechanical induced draught, it was found that in the latter case the average suction in the fan inlet was 1·40 in., the highest being 3·1 in. and the lowest 0·4 in. water gauge, giving 0·55 in. in the side flues. Temperature in the fan inlet: average, 420·5 deg. F.; highest, 665 deg. F.; lowest, 306 deg. F.

There is also a very strong difference of opinion as to relative merits of natural and mechanical draught. The actual figures found were 123 plants with chimney draught were working with a net efficiency of 58·5 per cent., 93 plants with steam-jet forced draught with 58 per cent. efficiency, and 32 plants with induced draught with 63·6 per cent. efficiency.

As with the question of mechanical *versus* hand firing a great many factors have to be considered before deciding as to whether natural or mechanical draught is preferable for a given plant, more particularly quality of fuel to be burnt, amount of steam required per boiler and the degree of skilled attention that the proposed mechanical draught would receive.

(N) *Estimation of* CO_2.—Out of the 250 plants, 225 were not equipped with CO_2 recorders, 15 were equipped with recorders in fairly good running order, and 10 were equipped, but the machines were out of order. One striking fact is the very large number of boiler plants met with that have been fitted with CO_2 recorders, and have been forced to discontinue using them because of their complicated character.

It is probably correct to say that the CO_2 recorder has given more trouble than any other instrument or appliance used in the boiler-house.

In order to get economical results it is, of course, necessary to have some form of CO_2 recorder on a boiler plant, but it must be used with discretion. To get the best results it is essential to have a high percentage of CO_2, say, between 12 per cent. and 16 per cent., but it does not at all follow that a high figure necessarily means high efficiency, makers statement notwithstanding.

The figures obtained for CO_2 by installing a CO_2 recorder on the 250 plants during the tests were as follow:—

			Per Cent.
1. Very good, over 12 per cent.	4	=	1·60
2. Good ...10 to 12 ,,	17	=	6·80
3. Medium ... 8 to 10 ,,	64	=	25·60
4. Poor ... 5 to 8 ,,	144	=	57·60
5. Very bad...under 5 ,,	21	=	8·40
Total	250		

That is, 66 per cent. of cases were below 8 per cent. The best record found was 14 per cent. average, and the worst 3·5 per cent. average.

(O) *Black Smoke.*—The following are the particulars as regards black smoke for the 250 plants:—

			Per Cent.
1. Good; practically no smoke at all	65	=	26·0
2. Fairly good	62	=	24·8
3. Medium	75	=	30·0
4. Bad	43	=	17·2
5. Chronic; almost continuous black smoke	5	=	2·0
Total	250		

Out of the 250 plants, 30 were fitted with some form of patent smoke preventer. Most of these smoke preventers consist of some arrangement for allowing air to pass up the back of the bars so as to add excess air to the smoke on the Bunsen-burner principle. In practice they give only the most moderate results, and the way to stop black smoke economically is obviously to consume it in the furnaces.

It is really quite a simple matter to prevent black smoke and to get increased economy at the same time. It should be noted that, although a highly efficient plant will in all cases be practically smokeless, it does not follow that a plant having bad black smoke is necessarily very inefficient. For example, a plant may be working very well in every respect, giving, say, 13 per cent. or 14 per cent. CO_2. A trifle less air going through the fires will result in smoke, and perhaps 16 per cent. CO_2; but when in this condition the plant would be very much more efficient than many other plants that are smokeless due to a large excess of air passing through the fires.

(P) *Boiler Pressure.*—Out of the 250 plants all varieties of average working pressure were experienced from 12 lb. (blow-off 30 lb.) to 200 lb. (blow-off 205 lb.).

The plants were divided as follow:—

			Per Cent.
1. Under 60 lb. average working pressure	45	=	18·0
2. Between 60 lb. and 80 lb. working pressure	71	=	28·4
3. Between 80 lb. and 100 lb. working pressure	55	=	22·0
4. Between 100 lb. and 120 lb. working pressure	35	=	14·0
5. Between 120 lb. and 160 lb. working pressure	37	=	14·8
6. Over 160 lb. working pressure	7	=	2·8
Total	250		

As most engineers are aware, the engines of the country are, on the whole, working at much too low a pressure from the point of view of economical utilisation of steam, and the results show 46 per cent. of boiler plants working at less than 80 lb. pressure.

(Q) *Fluctuations in the Demand for Steam.*—There is in many instances considerable fluctuation in the demand for steam, and in each case this was ascertained by reading the water meter every half-hour, and making a correction for difference in the gauge-glass levels. Some establishments, such as cotton or flour mills, have a very steady demand for steam from hour to hour, whilst others, such as paper mills, dye works, calico printers, bleachers and brewers, have very violent fluctuations. The worst example tested was 40 per cent. difference in hourly evaporation; that is, in 1 hour the evaporation would be 600 gallons per boiler per hour, and the next hour 1,000 gallons. In most cases such plants are running without sufficient margin of steam pressure for economical working.

(R) *Superheaters.*—Out of the 250 plants, 80 plants were fitted with superheaters, which includes 55 plants only partially fitted. Of the 80 plants fitted, the average temperature of steam was 316 deg. F., before superheating, and 366 deg. F. after, being 50 deg. F. of superheat. The highest temperature of superheated steam test was 650 deg. F. In the case of the 25 plants completely equipped with superheaters the average amount of superheat was about 120 deg. F.

The value of superheating is very little realised, either from the point of view of partial superheat of, say, 75 deg. F., to avoid condensation losses in the steam pipe circuit, or from that of complete superheating with a view to economical utilisation of steam in the engines or turbines. As seen, the average for the whole 250 plants was only 16 deg. F.

(S) *Annual Coal Consumption.*—In this respect the 250 plants were representative of different-sized plants, being divided as follow:—

			Per Cent.
1. Under 1,000 tons per annum ...	10	=	4·0
2. Between 1,000 tons and 2,000 tons per annum	26	=	10·4
3. Between 2,000 tons and 4,000 tons per annum	62	=	24·8
4. Between 4,000 tons and 7,000 tons per annum	54	=	21·6
5. Between 7,000 tons and 10,000 tons per annum	33	=	13·2
6. Between 10,000 tons and 20,000 tons per annum	41	=	16·4
7. Over 20,000 tons per annum...	24	=	9·6
Total	250		

As already indicated, the average price per ton delivered of the coal used on all the plants from 1910 is 14*s.* 6*d.* per ton, but to-day the price is considerably higher than this average, probably about 20*s.* per ton for the whole country, so that the coal bill in tons represents also the price in pounds.

(T) *Steam or Power used as Auxiliary to the Production of Steam.*—As already seen, out of the 250 plants, 127 were using steam or power as an auxiliary to the production of steam, 93 being steam jets under or over the bars, 32 as induced draught, and 2 as forced draught. Out of the 127 cases the average amount of steam so used was 4·7 per cent. of the production in the boilers, corresponding to 2·4 per cent. for the whole of the 250 plants. With regard to induced or forced-draught fans,

the average is approximately 2½ per cent. to 3 per cent. of the production.

With steam jets the amount varies very considerably, being anything from 1 per cent. to 20 per cent. of the production, the average on the 93 plants being 5·6 per cent. Where the jets are used as the sole means of obtaining a draught as in some types of patent fire-bar and mechanical stokers the amount is rarely under 5 per cent. and may be as high as 12 per cent. The author has come across one or two extraordinary cases. Thus one type of steam-jet apparatus had no less than sixty $\frac{3}{32}$-in. steam nozzles working at 100 lb. pressure per "Lancashire" boiler, using 1,302 lb. of steam per hour, whereas the total evaporation of the boiler was only 6,861 lb., so that the amount of steam used was nearly 19 per cent. of the production. In the types of stokers using steam jets to cool the bars the amount is generally between 2 per cent. and 4 per cent.

Very little attention has hitherto been given to this question of auxiliary power. In many cases where some form of mechanical stoker or fire-bar has been installed, on investigation the amount of steam used under the bars has been found to be equivalent to the cost of a complete new outfit every twelve months.

Assuming that 2·4 per cent. of the production is a correct figure for the coal consumption of all the boiler plants of the country, that is, 75,000,000 tons to 100,000,000 tons per annum, the amount used in this way is 1,800,000 tons to 2,400,000 tons per annum.

(U) *Efficiency of Plant.*—As seen, the average working efficiency for the whole 250 plants is 60·09 per cent., that is to say for every 100 lb. of coal put into the boiler fires 60·09 lb. are being used to produce useful steam, the other 39·91 lb. being wasted. The efficiency is split up into 56·71 per cent. for the boilers only, 4·35 per cent. for the economisers, and 0·51 per cent. for the superheaters, which, after allowing 2·4 per cent. used as auxiliary steam, gives a net working efficiency of 60·09 per cent.

It will be noted that 61 per cent. of the plants are working with an efficiency of less than 60 per cent., and that only 9·6 per cent. of the plants exceed 70 per cent. efficiency.

(V) *Cost in Coal to Evaporate* 1,000 *Gallons of Water.*—This figure, of course, depends to a large extent on the cost of coal in the locality, and is therefore not of much value in comparing the performance of boiler plants in different localities. The difference between the cost of coal in, for example, Staffordshire, as against the cost of the same quality of coal in London, is enormous.

Taking the whole 250 plants the efficiencies were divided as follow:—

		Per Cent.
1. Over 80 per cent.	2 =	0·8
2. 75 per cent to 80 per cent. ...	9 =	3·6
3. 70 per cent. to 75 per cent. ...	13 =	5·2
4. 65 per cent. to 70 per cent. ...	30 =	12·0
5. 60 per cent. to 65 per cent. ...	44 =	17·6
6. 55 per cent. to 60 per cent. ...	62 =	24·8
7. 50 per cent. to 55 per cent. ...	47 =	18·8
8. Less than 50 per cent.... ...	43 =	17·2
Total	250	

It is interesting to compare the average figures for the 250 plants with those in the original article of April 14 and 28, 1916, for 100 plants only. In the latter case, "Lancashire" boiler plants only were given as being more generally typical of the whole of the boiler plants of the country, whereas the 250 plants may be said to represent all types of plant roughly in the proportion as used in the country. The figures are given in the table at the top of the next column.

It will be seen that the figures agree very well. The net working efficiency of the 250 plants is 60·09 per cent., as against 62 per cent. for the 100 plants. In the latter case it was remarked at the time that probably 60 per cent. was nearer the true average for the whole country, which is borne out as the result of further experience.

The results on the 250 plants show less efficient figures for economisers and superheaters, whilst more auxiliary steam is being used.

It will also be interesting to give the average figures for some separate industries included in the 250 plants, as follow:—

—	Average of 100 Plants Complete ("Lancashire" Boilers).	Average of 250 Plants (all Classes of Boilers).
Duration of trial	10·66 hours	9·43 hours
Amount of coal used	26,994 lb.	30,131 lb.
Price of coal per ton	12s. 2d. in fire-hole	14s. 6d. in fire-hole
Analysis of coal used:		
British thermal units ..	12,680	11,822
Ash	9·3 per cent.	11·5 per cent.
Coal burnt per boiler per hour	791·3 lb.	798·8 lb.
Water evaporated	192,630 lb.	197,776 lb.
Water evaporated per pound of coal	7·13 lb.	6·56 lb.
Equivalent evaporation from and at 212 deg. F., per pound of coal	8·11 lb.	7·46 lb.
Temperature of feed water before economisers	117 deg. F.	116 deg. F.
Temperature of feed water after economisers	226 deg. F.	193 deg. F.
Coal bill saved by economisers	10·1 per cent.	7·1 per cent.
CO_2	7·5 per cent.	7·6 per cent.
Steam pressure:		
Gauge	93·5 lb.	89·0 lb.
Absolute	108·0 lb.	104·0 lb.
Temperature of saturation of steam	333·2 deg. F.	330·5 deg. F.
Temperature of superheated steam	369·6 deg. F.	346·5 deg. F.
Steam or power used as auxiliary to the production of steam	1·5 per cent.	2·4 per cent.
Thermal efficiency:		
(A) Net working efficiency after deducting steam used as auxiliary ..	62·03 per cent.	60·09 per cent.
(B) Boilers only	55·65 per cent.	56·71 per cent.
(C) Economisers only ..	6·24 per cent.	4·35 per cent.
(D) Superheaters only ..	1·08 per cent.	0·51 per cent.
Cost in coal to evaporate 100 gallons of water:		
(a) At average prices for coal	91·3d.	113·3d.
(b) At to-day's average price for coal of 20s. per ton	150·0d.	163·2d.

bill, with a temperature of 261 deg. F., in the feed water, as compared with only 7·1 per cent. saving for all industries. The efficiency of the boilers only is also very good, being 60·87 per cent. as compared with the average of 56·71 per cent.

The next best results are shown by the explosive factories, 22 plants, giving an average efficiency of 66·48 per cent. These plants have practically all been erected since the war commenced, and although a few of them were put up in a great hurry in emergencies, the majority of them have been most carefully erected on what is regarded as the most modern lines, and a number of them are certainly "show" jobs.

There is a general impression that bad working results on boiler plants are due to "old" plants, and that a new plant that has been erected only a few years is much more efficient. This is, of course, a complete fallacy and due to the fact that boiler plants have never been regarded from a scientific point of view. A given boiler plant is obtaining efficient results first of all because of correct design and secondly because of careful attention to the working.

The age of the installation has nothing to do with the efficiency of the results except that in a casual sort of way a plant of recent erection may have a few more economisers, and superheaters may be installed. Generally speaking, modern boiler plants are no more efficient than plants erected say ten years ago, because the science of economical steam generation is no more understood now than it was at that time. Thus 21 paper mills, almost all of which are old plants, certainly on an average fifteen years, are giving more efficient results than 22 explosive factories which have been erected on the most "modern" principles and which, on an average, are only about three years old.

—	75 Collieries.	20 Cotton Mills.	10 Lace Mills.	16 General Chemical Manufacturers.	22 Explosive Factories.	26 Dyers and Bleachers.	21 Woollen Mills.	9 Hosiery Mills.	21 Paper Mills.
Duration of trial .. .. .. hours	8·44	11·15	9·14	7·98	17·66	8·87	8·6	8·29	11·35
Amount of coal used .. .. lb.	41,851	28,773	13,897	11,939	210,741	17,744	17,462	15,251	37,558
Price of coal per ton (taken as)	20s.	20s.	20s.	20s.	20s.	20s.	20s.	20s.	20s.
Analysis of coal used:									
British thermal units	10,920	12,972	10,249	11,669	12,359	12,355	12,617	10,683	12,347
Ash .. .. per cent.	16·5	8·4	12·4	11·2	9·67	8·5	11·0	9·5	10·6
Coal burnt per boiler per hour .. lb.	807·6	806·4	661·0	680·0	220·0	778·3	822·0	766·5	787·8
Water evaporated .. .. .. ,,	226,630	213,606	69,059	77,000	1,581,480	114,241	119,973	89,243	294,933
Water evaporated per pound of coal ..	5·41	7·42	4·96	6·45	7·50	6·43	6·87	5·85	7·85
Equivalent evaporation from and at 212 deg. F. per pound of coal .. lb.	5·8	8·54	5·70	7·28	8·78	7·39	7·88	6·72	8·83
Temperature of feed water before economisers .. ..deg. F.	163·0	110·0	96·0	121·0	89·5	98·0	109·0	105·0	133·0
Temperature of feed water after economisers .. ..deg. F.	—	250·5	126·0	199·0	183·0	207·0	237·0	186·0	261·0
Coal bill saved by economisers per cent.	—	12·8	2·75	7·30	8·4	9·9	11·7	7·4	11·9
CO_2 .. .. ,,	8·0	8·1	6·5	8·0	8·7	8·2	7·1	7·0	8·2
Steam pressure (gauge) .. .. lb.	82·0	124·0	56·0	71·0	118·0	59·0	94·0	80·0	113·0
Temperature of saturation of steam deg. F.	325·0	352·0	304·0	317·0	349·0	307·0	333·9	323·9	345·9
Temperature of superheated steam deg. F.	—	415·0	—	357·0	401·0	320·0	345·4	346·6	412·8
Steam used as auxiliary .. per cent.	1·5	1·1	0·3	0·71	5·68	1·7	2·8	3·0	1·2
Thermal efficiency:									
(A) Net working efficiency after deducting steam used as auxiliary per cent.	51·2	64·97	53·76	61·0	66·48	57·20	58·97	59·57	70·67
(B) Boilers only	52·0	55·49	52·44	55·89	62·98	52·10	53·24	56·23	60·87
(C) Economisers only	nil	8·18	1·48	4·39	5·77	5·77	7·09	4·51	8·28
(D) Superheaters only	nil	1·02	nil	1·15	1·73	0·31	0·34	0·66	2·38
Cost in coal to evaporate 1,000 gallons of water per hour .. .. .. pence	197·8	144·3	215·6	166·1	142·4	166·4	155·9	183·1	136·4

There will be noted first of all the low efficiency of colliery steam boiler plants, only 51·2 per cent. as compared with the average of 60 per cent. for the whole country. Colliery plants from the point of view of economical steam generation are the worst of all plants, as would be expected from even a casual inspection of such plants. This is all the more surprising when it is borne in mind that apart from the boiler plant the general engineering of the average colliery is much more up to date than most other industries. One reason is presumably that in the past coal has been so cheap at the pit head as to be hardly worth saving.

The paper-making industry is giving decidedly the most efficient results, the average of 21 paper mills being 70·6 per cent., which corresponds to no less than 15 per cent. saving in the fuel bill as compared with the average for all plants. The chief reason of this good result is not so much due to more scientific methods of controlling the working of the plants as to the fact that good use is made of economisers and superheaters. Thus the average efficiency due to economisers is 8·28 per cent., corresponding to 11·9 per cent. saving in the coal

It will be noticed, however, that the efficiency of the boilers of the explosive factories is the best of all, but that the amount of auxiliary steam used is no less than 5·68 per cent., as compared with only 2·4 per cent. for all industries. Thus the modern plants are wasting much more fuel in this respect than the older plants, and, some of the newest of these plants show a shocking lack of economy, using often 15 per cent. and over of the steam produced, when 3 per cent. is ample for the most efficient results.

The cotton industry is also giving results considerably above the average, and like the paper-making industry utilises economisers and superheaters to very good effect.

The general chemical industry is obtaining results practically only equal to the average and much inferior to paper-making, cotton and explosives.

One would have expected that such an industry in which technical chemists are largely employed would have been most efficient in this respect and would have been an example to other industries.

This is, however, not the case, and the author (writing as a technical chemist) is of the opinion that the chemical industry is even more conservative and out-of-date than usual in adopting modern scientific methods of economical steam generation.

It will be observed also that woollen and hosiery mills are average, and lace mills and dyeing and bleaching works considerably worse than the average.

SUMMARY OF RESULTS.

The detailed analysis of the results will have been quite sufficient to show that the general methods of steam generation in this country are out of date.

No attempt is made to purchase fuel on scientific lines, on the actual heating value of the fuel supplied and its suitability for the particular conditions of the given boiler plant. No check is kept on the cost of production of a unit of steam and on the general performance of the plant. Thousands of factories are short of steam in spite of the fact that a very moderate amount of reorganisation of the boiler plant would give all the extra steam required from the same number of boilers and the reorganisation would be paid for in a few months by increased factory production. Thousands of boiler plants are being worked under shocking conditions as regards attention to repairs and up-keep conditions which would not be tolerated for a moment in connection with engines and general machinery.

The reason of this deplorable state of affairs is first because the question of the economical generation of steam is essentially the business of a specialist, comprising a combination of technical chemistry and engineering quite outside ordinary practice. It seems very probable that the conditions of steam generation in this respect are much the same all over the world. The author has examined a number of steam boiler plants in France, and the general working conditions appear to be very similar. In the United States the average working efficiency does not seem to be more than about 60 per cent., on a coal bill at the present time of certainly over 300,000,000 tons per annum.

Secondly, in Great Britain at any rate, the trouble is due to conservatism to a general disinclination to apply modern methods of applied science and organisation, a characteristic that applies to many other national questions besides that of coal economy.

SAVINGS TO BE OBTAINED.

The average net working efficiency of the 250 plants is 60·09 per cent., which the author contends is a typical figure for all the plants of the country.

Now a steam boiler plant run on modern scientific lines will give results of 75 per cent. to 82 per cent. efficiency with ordinary steam coals or coke depending on the particular conditions of the plant. With purely refuse fuels the best efficiency possible may be only, say, 65 per cent. to 70 per cent., but for all practical purposes 75 per cent. net working efficiency may be taken as the average figure to be obtained on continuous performance. This figure is based on the author's ten years' experience of scientific boiler-plant work, which includes the reorganisation of dozens of boiler plants, and is not a theoretical assumption.

Thus, in the 250 plants, 2 plants are already working at over 80 per cent. efficiency, 9 plants between 75 per cent. and 80 per cent., and 13 plants between 70 per cent. and 75 per cent., and the general working conditions of these plants are roughly no more different than the remaining 226 plants which are only working at about 57 per cent. efficiency.

Turning now to the amount of coal to be saved, taking first the exact figures of the actual 250 plants, the total amount of coal burnt per annum on these plants, consisting of 1,000 boilers, is 2,166,000 tons, with an average efficiency of 60·09 per cent. If these plants were reorganised on modern scientific lines and run on an average efficiency of 75 per cent., the annual saving would be, say, 430,000 tons.

Assuming now that the 250 plants are typical of the thousands of boiler plants of the country, then if all these plants were brought up to date and run on 75 per cent. efficiency, the saving would be 20 per cent. or no less than 15,000,000 tons to 20,000,000 tons of coal per annum.

Even if the worst industry of all, that of collieries was taken in hand alone, the national saving would be very large.

Out of the 287,000,000 tons of coal raised per annum (1913) about 20,000,000 tons are consumed by the collieries themselves, almost all of which is used for the generation of steam to provide power to raise the coal, or, say, 7 per cent. of the total output. We have already seen that the average working efficiency of colliery boiler plants is only about 51 per cent. If colliery boiler plants were reorganised to run on even the very poor performance of 60·09 per cent. efficiency (the average for the country) the saving would be 15 per cent., or 3,000,000 tons of coal per annum. If, however, these plants were taken in hand on scientific lines and reorganised to run on an efficiency of, say, 70 per cent. (allowing 5 per cent. loss in efficiency from the figure of 75 per cent. because of the varying quality of the fuel burnt at collieries), then the saving would be about 27 per cent., or, say, 5,400,000 tons of coal per annum.

Even in the case of the more up-to-date industries the aggregate saving possible is very large. Thus, taking the case of electric generating stations, which are supposed to be very efficient, it will be no exaggeration to say that the average saving possible in all the 600 or more power stations in the country is 10 per cent. of the fuel bill by the more economical generation of steam.

As already pointed out, the question of coal economy is doubly important, first as an immediate war measure, and secondly, including the first, as part of a great national scheme of reorganisation essential to our future progress.

What is required at once is that a quick survey should be made of all the boiler plants of the country by the few real experts on the question we possess.

This work cannot be done by amateurs or by people who are unused to technical conditions and organisation. When such a rapid survey has been made an immediate reorganisation of the largest and most wasteful of the boiler plants of the country should be carried out, together also with the utilisation of the large stocks of refuse coal at many collieries for boiler plants working under easy conditions as regards steam output. There is not the slightest doubt that at least 500,000 tons of coal per annum could be saved in this way, commencing in six months time, and the necessary labour and material for the reorganisation would be very small in comparison to the national saving obtained. If priority certificates for plant and machinery were granted only to work of real national importance the labour and material required for reorganising existing steam boiler plants on the above lines would be far less than that now taken up by work of no importance whatever. Such a scheme would have the additional advantage of releasing a large number of steam boilers, probably 300 to 400 in six months, and economising steel now being used to make new boilers, as the reorganisation would include the shutting down of many boilers and working the remaining boilers at the proper steam output. The cost of the reorganisation could, if necessary, be borne by the Government and would, in fact, be a most profitable investment.

The larger question of a great national scheme of economical utilisation of our coal resources requires the most careful and thorough investigation with a vast amount of experimental and research work, and we have urgent need of every experienced man in the country to unite and concentrate upon it.

Whatever national method or methods of reorganisation is finally adopted for power production it has to be remembered that a very large amount of steam will always be required in industry for heating, boiling, and general technical processes quite apart from power production, and this amount will probably correspond to between 15,000,000 tons and 30,000,000 tons of coal per annum. The question of the economical generation of steam will, therefore, always be a very important part of the greater national scheme of coal economy, even if all the power in the country is generated by gas engines and the by-products of the distillation of coal. In such an event the fuel for steam raising will probably be chiefly coke and coke breeze. If, however, it is decided that a large part of our power is to be produced by steam plant, then the question of economical steam generation will be of still greater importance.

In any case the immediate reorganisation of the largest and most inefficient plants could be undertaken chiefly in connection with those plants which will always require to produce a large amount of steam for purposes other than power production, so that the reorganisation would fit in with the future and larger scheme of national coal economy to be applied to the whole country.

THE CUNARD NATIONAL SHELL FACTORY.

(*Concluded from page 6.*)

IN our previous article we described in detail the successive operations in the manufacture of the smaller shells, with special reference to the adaptation of ordinary lathes for particular work, and now we propose to follow the same procedure in connection with 8-in. shells. The first operation—parting to approximate length,—is the same in all cases. For the second operation—rough-drilling the fuse hole—a special bed plate is fitted to a vertical drilling machine (of steam-hammer design), constructed with a sliding carriage operated by rack and pinion. To the above carriage are secured two centring mandrils, fitted with spring-loaded cone pieces, shaped to take the internal contour of the shell. Two stop pieces are fitted on the rack to bring either of the centring mandrils directly under the drilling spindle. The shell is placed on a mandril and a hole drilled through the nose, accurately centred from the bore.

The third operation—rough-turning the body and nose—is shown by Figs. 27 and 28, Plate IX. After a hardened steel centre piece has been fitted in the nose end, the open end of the shell is placed in the chuck and the lathe tail stock centre brought into position. The chuck is shown in Fig. 27, and is of the same general description as that used for the 4·5-in. and 6-in. shells, referred to in the preceding article. After the parallel portion of the body has been rough-turned, the shell is then rough-nosed, whereby the heavy work is taken off the former plate at a later operation when the body is completely machined. A cast-iron curve plate is fitted, as shown in Fig. 28, between the shears of the lathe bed and a roller bracket attached to the lathe saddle which permits the operator to work up to the curve plate. Before fixing the curve plate, the position of the cutting tool must be taken into account.

Roughing and finish boring is the next, the fourth operation, and the adaptations of the lathe are shown by Figs. 29 and 30, Plate IX. The shell is secured in a self-centring chuck, with cone locating seat at the bottom. The usual tool rest is removed, and a cast-iron swivel bar holder fitted. On the end of the bed of the lathe there is secured by cross plates and bolts, a cast-iron former carrier, machined to take curve plates and rollers (Fig. 30). The path of the cutting tool fitted in the end of the bar is controlled by the former plates, four rollers being attached to the bar—two working vertically and two horizontally. The latter rollers work inside the curve plates, and thus determine the path of the tool at the cutting end of the bar. The vertical rollers steady the bar and take any undue load from the lathe saddle. The feed is obtained from the leading screw. By this method of boring, a cheap simple, single-ended tool is used, instead of a large and expensive cutter. The boring bars, by the way, were manufactured from the old piston rods of the Lucania.

The fifth operation—boring, facing and tapping the nose end of the shell for the adaptor—is done by the aid of the fitting shown in Fig. 31, page 58. The shell is placed on an expanding mandril, spiggoted and secured to the lathe face plate. The mandril end is shaped to the internal contour of the nose end of the shell, the expanding dogs securing and accurately centring the shell. A cast-iron sleeve fits in a steadyment over the mandril, and takes any undue weight off the latter. The finish turning of the body and profiling of the projectile is done in a manner similar to that adopted in the case of the 4·5-in. and 6-in. shells. Fig. 32, Plate X, illustrates

the arrangement for profiling shells on an ordinary engine lathe. It shows the attachment of the profile copy plates, adjustable slide, supporting brackets for slides, and roller plate bracket to an ordinary screw-cutting lathe. It will be noticed that the surfacing screw has been removed, and that the top tool rest is turned, making an adjustable cross feed. The longitudinal feed is actuated by the leading screw, and tool rest being governed by roller bracket, the path of the cutting tool must follow the curve plate. The position of the curve plate must bear a direct relationship to the tool, and to allow for adjustment elongated slots are provided in the slides. Fig. 33 shows the adjustable copy plate for profiling the 8-in. shells. The former plate is supported on a cast-iron bracket along with the roller and pin. Elongated slots are left in the underside of the copy plate bracket to allow for adjustment when setting, and tapered collars are fitted to allow the copy plate to be adjusted to take up wear.

After the shell has been secured in a self-centring chuck, a facing cutter fixed in a stout bar faces the base end to the required length, which is the seventh operation. After this, the recess to take the base adaptor flange is machined, and the undercut made to relieve the thread milling cutter.

The eighth operation is thread milling for the base adaptor. The shell is centred from the outside diameter. A hob cut to the required pitch is revolved in a stationary headstock fitted with cross-traverse feed, which enables the exact depth of the cut to be gauged. The shell carriage is rotated by means of worm gear, and on the completion of one revolution the master nut brings the carriage one pitch forward, thus making a complete thread. For the ninth operation, recessing, undercutting and wavy serrating for the copper band, a screwed centre piece is screwed into the base of the shell before it is placed in the coned chuck and loose tail stock centre brought up into position, as in the case of the 4·5-in. and 6-in. shells (see Fig. 34, Plate X).

The machining of the base adaptors is effected by an arrangement of tools as shown in three details in Fig. 35. The adaptor is gripped by a square (on the back of the same) in a four-jawed chuck, and completely machined in one setting; thus ensuring that the diameters are concentric and the faces at right angles to the axis. The adaptor was specially designed with a square to obtain these results. In thread-milling the base adaptor, the flange is gripped in a strong four-jawed self-centring chuck, while the back face is brought hard against a jig to ensure accurate setting. The thread is then produced by a rotating hob.

The base adaptor is fitted into the shell by hand, and it is then secured in a stout grip and driven home. The copper band having been pressed into position, the shell is chucked, the adaptor square parted off, and the base end faced and the shell re-centred. A chuck, bored to the form of the head, is screwed to the lathe cone spindle, and the shell is placed in the chuck, and the loose tail stock centre brought into position. The band is then turned to the required diameter and form, with straight roughing tool, and circular-form tools. The shell is then placed in a grip and the nose adaptor screwed into position. The shell is next weighed, and if found heavy, the required amount is faced off the base end. A hardened steel centre is screwed into the fuse hole, the base end of the shell gripped in a four jaw self-centring chuck, and the tail stock centre brought up into position. The nose adaptor is then blended to the profile of the shell body.

The other operations — examination, washing, varnishing, storing bonding, and painting and despatching, are similar to those followed in the case of the 4·5-in. and 6-in. shells.

In view of the fact that the work was to be done entirely by female labour, the lifting and transporting appliances received careful consideration. In the case of practically all lathes on which heavy shells were machined, lifting gear was fitted as illustrated on Fig. 36. This, it will be seen, is a simple cast-iron footstep bracket, fitted on the end of the lathe bed, and made secure by cross plates and bolts. In this footstep there is fitted a machined steel forging, stepped to allow the T-bar to be attached; the upper end of the jib being drilled to take a shackle for suitable easy-purchase quick-lift chain blocks.

THE CUNARD NATIONAL SHELL FACTORY.

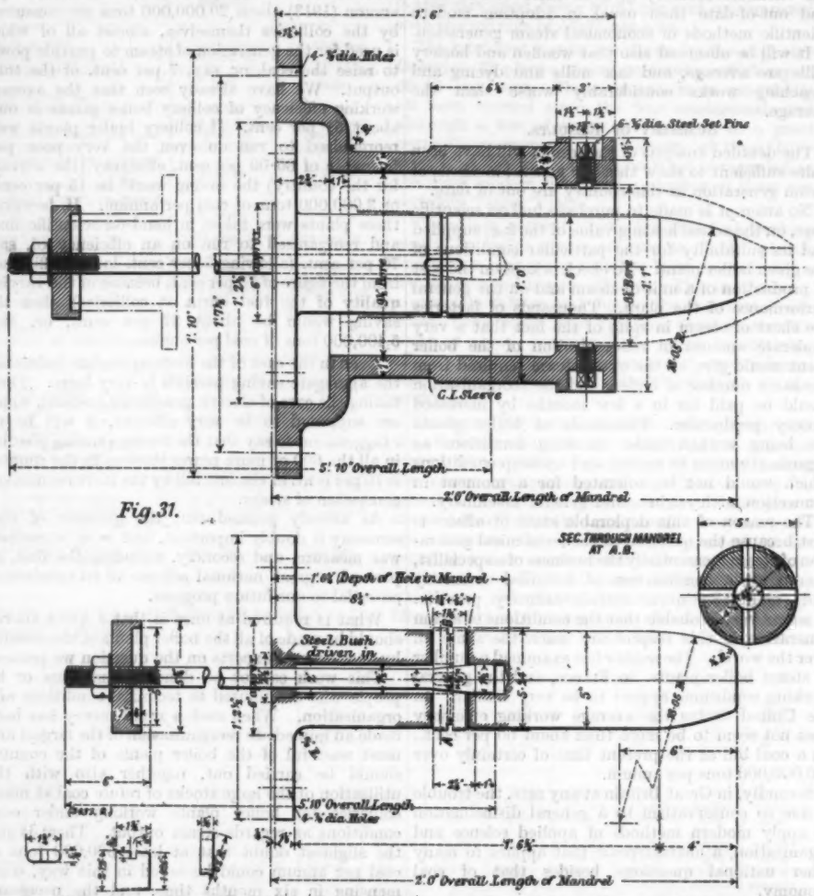

4-¾ dia. Holes
6-½ dia. Steel Set Pins
C.I. Sleeve
5' 10" Overall Length
2'6" Overall Length of Mandrel
Fig. 31.
SEC. THROUGH MANDREL AT A.B.
1'6" (Depth of Hole in Mandrel
Steel Bush driven in
5' 10" Overall Length
6-¾ dia. Holes
2'6" Overall Length of Mandrel

FIG. 31. MANDRIL AND CAST IRON SLEEVE FOR BORING AND FACING NOSE-END OF 8-IN. H.E. SHELLS.

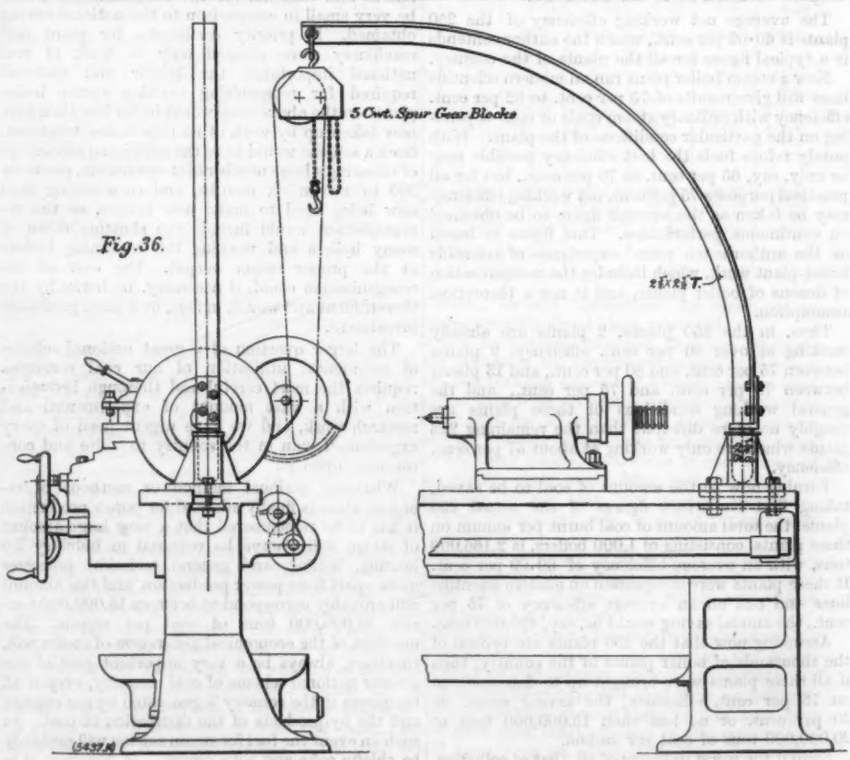


FIG 36. CRANE ON LATHE BED.

THE CUNARD NATIONAL SHELL FACTORY.

Fig. 37.

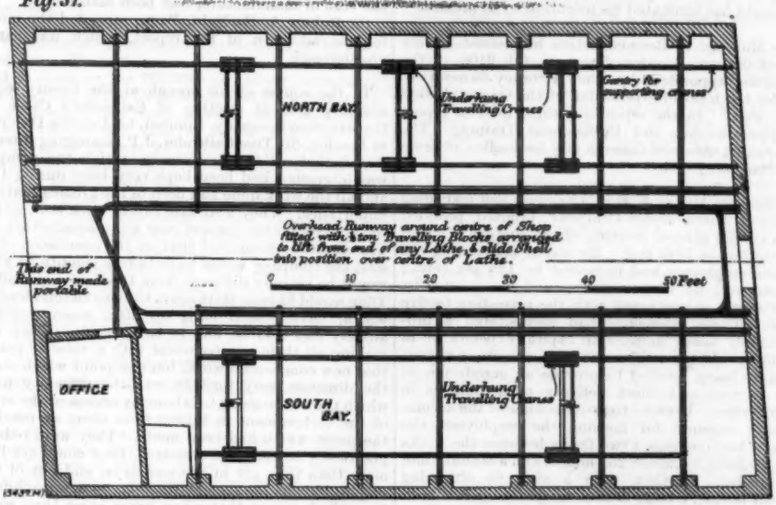

NORTH BAY.
Underhung Travelling Cranes
Gantry for supporting cranes
Overhead Runway around centre of Shop fitted with 5 ton Travelling Blocks, arranged to lift from end of any Lathe & slide Shell into position over centre of Lathe.
This end of Runway made portable.
0 10 20 30 40 50 Feet
OFFICE
SOUTH BAY.
Underhung Travelling Cranes

FIG. 37. HANDLING APPLIANCES IN 8-IN. SHELL DEPARTMENT.

FIG. 38. THE DINING ROOM.

Runways were provided in the centre of the shop, for the heavier shells, and in the wings there were light travelling cranes, erected in sufficient numbers to avoid delays in handling the shells. The arrangement of these is well shown in Fig. 37.

The factory is self-contained, and manufactures all tools and jigs or other appliances required for the three types of shell. Special attention was given to the laying out of the tool room, blacksmith's shop, tempering furnaces, &c. In order to keep the plant in good running condition, well-equipped millwright and electrician shops were provided. To avoid delay, tool stores were arranged on each floor, with a girl in charge. It is the duty of the tool room to see that each department is properly equipped at all times with complete sets of the tools required for each operation.

Owing to local conditions, one-half of the machinery is operated by motors using direct current and the other half by motors working on alternate current, a sub-station for the latter being included in the works. For the lathes manufacturing 8-in. shells single pulley drives were adopted.

As we have already said, the staff was organised at the outset of the operations, and none of those employed had any previous experience of shell-making. The foremen started as ordinary turners. It was originally intended to manufacture 18-pounder and 4·5-in. shells, but when the arrangements were finally completed, the Ministry of Munitions stipulated for 4·5-in. and 6-in. shells, and before the factory was actually going, 8-in. shells were added to the programme. In view of the shortage of skilled labour, it was decided to employ female labour, rather than introduce semi-skilled or unskilled men. It was considered that given an intelligent type of girl of good education, and provided that proper lifting appliances were put down, equally good results would be obtained. As a matter of fact, with careful training, better results were obtained, and it was not found necessary to fit the lathes with "fool-proof" devices, in other words, the accuracy of the work turned out was left to the judgment of the operator. The operators had the honour of manufacturing the first 6-in. and 8-in. shells made in Great Britain with female labour.

As a result of this, the Ministry insisted on female labour being introduced into similar factories, and quite a number of deputations were received from other parts of the country, in order that they might be quite satisfied that all that was claimed was being done. The percentage of female labour employed in the factory has advanced from 80 per cent to 90 per cent.

The girl operators work in three shifts: (1) 7 a.m. to 3 p.m.; (2) 3 p.m. to 10 p.m.; (3) 10 p.m. to 7 a.m. On Saturdays, one shift works from 7 a.m. to 12 p.m. and another shift works from 12 a.m. to 5 p.m. Skilled men work 12-hour shifts. Operators received a minimum wage, and are also paid bonus on an agreed scale.

Excellent kitchen and dining-room accommodation is provided. A hot lunch is served in the middle of the day, also a substantial tea. For the night shift, a meal similar to that provided in the middle of the day is available at 2 a.m. Dining accommodation is also provided, and a view of the dining-room is given in Fig. 38, annexed. A rest room is provided and is used also in case of accidents. The services of a surgeon are available in serious cases, but these, fortunately rarely occur. A matron looks after the welfare of the girls. A recreation room is provided, which is fitted with a stage and accessories, and can, on occasion, be turned into a theatre. On each shift of operators concert parties have been formed for the entertainment of wounded soldiers, &c. Cloak rooms are provided for each shift and hot and cold water is available. Special care has been given to the ventilation of the factory, as a whole, and the same remark applies to the heating of the building. Wherever possible, labour-saving devices have been introduced. All the lubricant used for boring is distributed throughout the factory from a tank on the top floor.

ADMIRALTY CONTRACTS. STEEL MATERIALS.—The attention of all Admiralty contractors and sub-contractor is drawn to the procedure to be observed in ordering steel materials. It appears that in certain districts a considerable quantity of steel required for Admiralty purposes is still being placed through merchants instead of directly with the steel rolling firms when ordered in bulk, or with stockholders approved by the Steel Superintendent for small lots urgently required. The printed instructions recently issued on procedure for obtaining steel provide that it is incumbent on all firms requiring steel to consult with the Steel Superintendent of their district as to placing orders for steel, and to follow his instructions. It is equally incumbent on all firms having such requirements, to place their orders directly with the steel rolling firm or, in the case of small lots urgently required, with an approved stockholder, following the directions given by the Steel Superintendent. The practice of placing bulk orders with the rolling firms through a merchant or any other intermediary is strictly prohibited and payment of commission to a merchant in respect of any such order will not in any circumstances be allowed by the Admiralty as a charge against Government funds. The principal Admiralty stockholders hold a comprehensive stock of standardised sections, plates, sheets and bars which is reserved by them exclusively for Admiralty purposes, primarily for urgent ship repairs. Where delivery or completion of contracts is retarded for want of small quantities of steel, the authority of the Steel Superintendent should be asked to obtain the quantity necessary to cover immediate requirements from a stockholder. These stocks are not to be drawn upon for bulk orders, but only for small lots very urgently required. The above instructions apply to steel of ordinary, ship, boiler or constructional quality. The services of merchants and stockholders may be allowed, in the case of the following:—(1) Orders for special quality steels. (2) Orders for lots under 10 tons in total weight for any one ship or contract, or under 2 tons of any one size. (3) Orders for tin, terne, or blackplate. (4) Orders for delivery ex merchant's stock yards or warehouse.

INDUSTRIAL NOTES.

THE Director of the Department of Labour Statistics, dealing in *The Labour Gazette* with the labour market, states that in the textile industries, especially the cotton trade, there was a good deal of short time in June. In nearly all the other industries the demand for labour was very great, and much overtime was worked.

Trade unions with a net membership of 1,117,241, excluding those serving with the forces, reported 8,154 (0·7 per cent.) of their members as unemployed at the end of June, compared with 0·9 per cent. at the end of May, and 0·4 per cent. at the end of June, 1917. The increase in the percentage as compared with a year ago was almost entirely due to the cotton industry.

Of the 3,797,223 male and female workpeople insured under the National Insurance Acts, 1911 to 1916, the number unemployed at the end of June was 30,080, or 0·79 per cent., compared with 0·87 per cent. in the previous month and 0·72 per cent. a year ago. For males and females separately the percentages unemployed at the end of June were 0·36 and 1·74.

The average weekly number of vacancies notified to all Employment Exchanges for the four weeks ended June 7, 1918, was 43,948, as compared with 44,054 in the previous four weeks, and with 35,098 in the four weeks ended June 8, 1917. The average weekly number of vacancies filled for the same periods was 33,558, 33,898 and 28,270 respectively. The number of workpeople remaining on the live register at June 7, 1918, was 30,899 men, 60,997 women, 7,925 boys, and 8,147 girls, a total of 107,968.

The increases in rates of wages (including war bonuses) reported as having been granted during June resulted in a total increase of over 550,000*l.* per week in the wages of about 1,500,000 workpeople.

About 1,200,000 of these workpeople are accounted for by advances granted to colliery workers in Great Britain generally, and to operatives in the cotton industry. In the case of colliery workers the war wage granted in 1917 was increased from 1*s.* 6*d.* per day to 3*s.* per day for workpeople 16 years of age and over, and from 9*d.* per day to 1*s.* 6*d.* per day for workpeople under 16 years of age. In the cotton industry a further increase of 25 per cent. on list prices was given, making a total advance, during the war, of 60 per cent. on list prices. Other important changes were advances to men employed in the carting industry, to painters, polishers, dopers, and semi-skilled and unskilled men and boys in the aircraft industry, to workpeople employed in brick, tile, pipe, &c., manufacture, to workpeople in the flour-milling industry, to linen and jute operatives in Scotland, and to hosiery workers in the Midlands.

The number of disputes beginning in June was 86, and the total number of workpeople involved in all disputes in progress was 70,100, as compared with 86,000 in the previous month, and 25,800 in June, 1917. The estimated total aggregate duration of all disputes during the month was 375,100 days, as compared with 423,000 days in May, 1918, and 192,700 days in June, 1917.

The forty-sixth annual report, for 1917, recently issued by the United Patternmakers' Association, shows a total membership of 10,000 and a reserve fund of 134,491*l.* Unemployment during 1917 is returned as 0·09 per cent., as compared with 0·2 per cent. in 1916, 0·9 per cent. in 1915 and 4·1 per cent. in 1914.

The thirty-sixth annual report, for 1917, recently issued by the Ship Constructors' and Shipwrights' Association, shows that the membership at the beginning of the year was 30,970, whilst on December 31, 1917, it was 35,723. The income of the association for the year, apart from the operations of the society under the National Insurance Acts, reached the total of 93,933*l.*, which is an increase of over 10,000*l.* on that of 1916. The expenditure for the year was 58,998*l.* The balance in hand at the beginning of the year was 194,765*l.* The balance in the reserve fund at the end of the year was 229,700*l.*, which is clear of the amount in the political fund, which latter now stands at 5,050*l.*

The first meeting of the Joint Industrial Council for the rubber manufacturing industry was held at the Ministry of Labour on the 16th inst. Sir David Shackleton, K.C.B., welcomed the representatives present, and congratulated them on the way in which both parties had worked together in forming the Joint Industrial Council. He regarded it as very important that employers and members of trade unions should meet regularly to discuss subjects other than questions of wages, important though these were. Mr. James T. Goudie, of Preston, was elected chairman of the council and Councillor Jack Jones, London, vice-chairman. It was decided that a scheme for setting up District Councils should be prepared by a sub-committee for consideration at the next meeting. Mr. Adams, of the American Department of Labour, who is specially considering the establishment of Whitley Councils, subsequently addressed the meeting and said that he was very glad to be present on that occasion. They on their side were working in the same direction in these matters as we were in this country.

A public meeting will be held in the Mansion House on Wednesday, July 31, at 3 p.m., in furtherance of Mr. Hodge's scheme to raise a voluntary fund of 3,000,000*l.* for the re-establishment of disabled men. The Lord Mayor will preside, and H.R.H. the Duke of Connaught has intimated his intention to be present.

The Ministry of Reconstruction has issued, at the price of 6*d.* net, a series of reports, Cd. 9100, of the committee appointed by the Attorney-General to consider the legal interpretation of the terms "Period of the war." In the series is a third interim report on Apprenticeship and Professional Training. The series can be obtained through any bookseller, or from H.M. Stationery Office.

Sir Herbert Austin, K.B.E., chairman and managing director of Austin Motor Company, Limited, presided at the annual general meeting of the company, which was held on the 11th inst. He stated that during the year the employees had increased by 125 per cent.; the turnover, by 97 per cent.; and the assets, by 67 per cent., as compared with the preceding twelve months. These extensions had necessitated a proportionately heavy increase in capital expenditure in the works. About 60 acres in the company's vacant land were being levelled to provide an aerodrome on which to test and effect delivery of aeroplanes in running order. In order to provide some of the accommodation required for housing the employees, the company had purchased two farms between the works and the village, on which 252 houses and a laundry had been erected. Further, with a view to obtaining sufficient labour, a large fleet of motor-buses had been built and were running to various centres. These extensions had made it necessary to engage suitable staff to control the work, and throughout the whole of the period, the company had endeavoured to keep in view a programme for post-war operations which would enable the company to employ and make use of their three works, and, as far as possible, all the staff and employees. They had drawn up a definite scheme, settled on the various articles they intended to manufacture, had designed and prepared models, and they were now actively engaged in fixing up suitable relationships with agents and representatives in all parts of the world in which it will be possible for them to operate when peace is declared. Sir Herbert considered that they had to-day one of the most complete and efficient works organisations in the Empire, and the company expected to be able to occupy a very strong and important position in the markets where the sale of the goods they had decided to manufacture will be effected.

Presiding at the fourth ordinary general meeting of the Mond Nickel Company, Limited, held in London on the 11th inst., Mr. Robert Mond, J.P., stated that the great drain on man-power had during the year accentuated the labour shortage, and the ever-increasing demand for material for essential war industries had made the board's difficulties much greater in securing the necessary supplies for extensions. He regretted, therefore, that during last year they had not made that rapid progress which they had hoped for in completing the new extensions at Clydach. Although considerable advance had been made with the erection of the fifth unit against almost overwhelming difficulties as regarded lack of labour and dearth of material, the directors hoped that they had now reached the extreme limit of the difficulties with which they had to contend.

In Canada the management had also suffered from scarcity of labour and of essential supplies. In spite, however, of the great shortage of labour, the most severe winter ever experienced, and the great difficulty of obtaining supplies, they had been able not only substantially to increase their output of Bessemer matte, but also to put themselves in a position to supply the the intended increase of their refining plant. The management in Canada had vigorously pursued the policy of extended exploration, both by development and diamond drilling of the company's mining properties, and their already very considerable ore reserves had been very largely augmented by the finding of additional quantities of ore of very good grade, so that their future supplies of ore were secured for very many years to come.

In spite of the anxious times in which we lived, the board had been able by skilful management, both in Canada and in this country, and the whole-hearted co-operation of labour, to maintain the utmost capacity of the existing plant. As the company's business was one of vital importance for the production of nickel for war purposes, and of copper sulphate for agricultural use, they had been permitted to retain a sufficient force of labour to attain this result. Their supplies of matte in Canada for the refinery had been brought across the Atlantic without interruption, and the Government authorities had provided the company with the necessary permission for securing the requisite material to maintain the plant in full working order. In view of their sustained output and the slightly increased price of copper sulphate, the result of the year's trading, notwithstanding the great increase in the cost of manufacture, had been satisfactory.

Sir Robert A. Hadfield, Bart., seconded the motion for the adoption of the report, which was carried unanimously.

In the course of his speech at the twenty-second ordinary general meeting of Callender's Cable and Construction Company, Limited, held on the 11th inst., in London, Sir Tom Callender, J.P., managing director, stated that all the factories in which the company was interested had been kept very busy during 1917, and all the work done had been of the greatest national importance. They were also full of work now, so that the outlook for the present year was a satisfactory one. The directors recognised that on the conclusion of the war, the company would have to face conditions which would be entirely different from those now prevailing. They would have to start again the commercial business which, having been built up after many years of anxiety and trouble, had to be set aside. They were making all their arrangements with a view to getting that new commercial work, but one point which struck the directors very forcibly was the difficulty under which they were going to labour by reason of the action of the Government in taking from them so much of the profit which had been made. They were reduced practically to their old standard, they could get little more than they got in pre-war days, and out of that surplus they had to spend large sums on new machinery, &c., which meant that when peace came they would not have sufficient funds to be able to fight the enemy whom they would certainly have at their gate. They recognised the soundness of the financial policy of the Government, but regretted that the very sound policy which had been adopted would cause considerable inconvenience to the company and to other manufacturers in many lines of business when they resumed their commercial trade.

The Miners' Federation held a conference at Southport last week. At the meeting of the 12th inst, the following resolutions from the South Wales Federation were, we are informed, adopted at a private session:—

"In view of the possibility of a fall in the standard of living after the war as compared with pre-war standards, this conference decides to instruct districts to refrain from entering into any agreement after the declaration of peace which does not make provision for the continuance in the wage rate of all advances in wages paid either in consequence of a rise in the average selling price of coal, or of advances given to meet the increased cost of living due to the war."

"Whereas the advent of the present form of Governmental control of mines has resulted in the legal restriction of both prices and profits, it is now clear that the present Conciliation Board procedure must be ineffective in securing further advances in wages in consequence of controlled selling prices. Therefore, this Federation decides that the machinery for dealing with the general wage ought to be centralised in the National Federation."

The rates of wages and the alterations in the rates have so far been regulated by Conciliation Boards, and the operation of the latter has been limited to particular areas.

An important decision affecting the interests of manufacturers was arrived at last week, the Federation of British Industries, the British Empire Producers Organisation, and the Imperial Council of Commerce having formed a Joint Council: (1) To consider and report upon any questions of mutual interest reflecting the common aims of the three bodies, viz., To ensure the conservation and development of the industry, production and commerce of the United Kingdom and her Overseas Dominions, and submitted by any one of the three constituent bodies. (2) To initiate the consideration of any such subject, and (3) To take any action in relation to such subjects that may be specifically authorised by the constituent bodies.

The association of the three organisations, says the Federation of British Industries, should have a very marked effect on the future of British industry, as by means of the Joint Council concerted action will for the first time be possible between accredited bodies representative of the business interests—both industrial and commercial—of the United Kingdom and the

Overseas Dominions. It is obvious, they add, that any recommendations which may be made by such an association on imperial questions, such as the conservation of raw materials within the Empire, will carry great weight with the Government. The industrial organisation of the Federation of British Industries will enable each industry and trade within the United Kingdom at any time effectively and rapidly to submit its requirements and views to a body which fully represents the varying claims of the Empire, and conversely the Joint Council will be able to obtain without delay the views of any trade when Imperial questions affecting sectional interests are under its consideration.

The following are some recent decisions given by the Committee on Production on cases which have been referred to them by the Ministry of Labour, including cases arising out of the Orders under which a bonus to munition workers has been given: *Dock Labourers (Ireland).*—Casual men paid at hourly rates are to receive advances of from ½*d.* to 1½*d.* an hour, and the weekly paid men advances of from 4*s.* to 7*s.* a week at the ports of Belfast, Dundalk, Newry, Waterford and Londonderry, from first pay following June 21, 1918. *Shipbuilding Trade.*—Riveters, platers, caulkers and angle-iron smiths employed on Admiralty work (new and repair) at "Lieu" rates are to receive an advance of 20 per cent. from first pay after June 27, 1918, provided that this advance shall not be paid in cases in which "lieu" rates have already been increased independently of general war wages advances awarded by the Committee on Production.

"LUBRICATION OF MICHELL BLOCKS."

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of June 28 the article on "Lubrication of Michell Blocks" requires a slight correction: Second column, line 15 from bottom, should read "well forward of centre of block," instead of "well forward of the leading edge." Further, I suppose the last line in the first column reading "distance of any point of the block from the origin" is intended to mean "distance of any point of the block from the trailing edge" which, of course, is borne out by the subsequent text.

It would also be interesting to know whether the writer of the review B.B.C. (Brown, Boveri and Co.) article, when introducing the variation of viscosity by the expression $\lambda = \lambda_0 \left(1 + \frac{n}{a} x\right)$ takes as viscosity simply that quality which is defined as the "ratio of shearing stress to rate of distortion" or whether he means it to include also those additional factors which go to make up what one now is inclined to speak of as "oiliness."

I am, yours faithfully,

H. OXLIN.

Leagrave (Beds.), 2, Cumberland-road, July 12, 1918.

[Our correspondent is quite right, "leading edge" having been by a slip of the pen substituted for "centre of block." The writer in the Review B.B.C. uses the term viscosity in its ordinary sense and not as equivalent to oiliness.—ED. E.]

FOUR-CYCLE *versus* TWO-CYCLE DIESEL ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—Your leading article of June 28, on the relative merits of four-cycle and two-cycle Diesel engines, deals only with the experience of one manufacturer, and should not therefore be treated as conclusive evidence of the superiority of the former. We have certainly obtained more satisfactory results than those you mention with our two-cycle design, and after lengthy experiments and trials decided to make this type our standard for marine purposes, mainly for the following reasons:—

1. Almost double the power can be obtained from a given size of cylinder, resulting in lighter and cheaper construction, and the possibility of building engines of large output.
2. Smaller number of cylinders, reducing the length of crankshaft, number of cranks and risk of synchronising torsional oscillations. Less space required for the same output.
3. More even turning moment, with lighter flywheels.
4. Simplified reversing gear.
5. No exhaust valves to get out of order through the temperature of exhaust gases; the cylinder cover a simple and symmetric casting, which can be more effectively cooled.
6. Smaller number of valves and fewer spares required.

Apart from the starting valve the four-cycle engine you refer to had five valves in each cylinder cover (two exhaust, two inlet and one fuel valve). Our two-cycle engine with port scavenging has only a fuel valve. The former therefore had altogether 40 valves, whereas our two-cycle would only have 6, corresponding to 6,000 and 1,800 valve operations per minute respectively. The two-cycle engine tested had probably four scavenge valves per cylinder, or 30 valves in all, and the number of valve operations was 9,000 per minute. When one realises that the four scavenge valves in each cylinder open and close simultaneously in a hundredth part of a second, it is easy to account for the adverse opinion formed in regard to noise. We find no difficulty in silencing the suction of the scavenge pump of a two-cycle engine.

7. There is very little difference between the fuel consumption of our four-cycle and two-cycle engines; in fact, at lighter loads and reduced speeds (cruising speed) the consumption of the two-cycle is more favourable.
8. The two-cycle engine is better adapted for burning inferior fuels, since there are no valves opening into the combustion space and even tar oil can be used at all loads without any special appliance.
9. Equally high piston speeds are admissible for both types of engines.
10. With properly-designed scavenging ports and an effective system of re-charging the cylinders with air, the two-cycle has a greater overload capacity than the four-cycle. The figures you mention, as also the running at reduced speeds, seem to show a weakness in the design of the two-cycle engine referred to.
11. The lubricating oil consumption is lower. Actual results on a 4,000 brake horse-power engine taken over a number of months show a consumption of only 0·0054 lb. per brake horse-power hour.
12. For continuous operation the two-cycle has decided advantages over the four-cycle, as there are fewer working parts requiring periodical cleaning.

We admit these reasons appear to be in direct contradiction to the views expressed in your article, but the fact that 245,000 brake horse-power of our two-cycle design have been built within the past few years speaks for itself, and scarcely endorses your statement that this type of engine has not gained ground. This output has already outstripped that of the four-cycle engine we have built for sixteen years by some 27,000 brake horse-power, and although we continue supplying this type for certain purposes up to 250 brake horse-power per cylinder, we have two-cycle engines running successfully up to 650 brake horse-power per cylinder, and have satisfied ourselves that even larger units are possible by building an experimental single cylinder of 2,000 brake horse-power. For ship propulsion where simplicity, reliability and ease of manœuvring are of paramount importance, we are convinced the two-cycle offers the greatest advantages, and this opinion we have formed after extensive experience with both types.

Yours faithfully,

(SULZER BROTHERS),

F. SCHUBELER, M.I.M.E., Manager.

30, Norfolk-street, Strand, London, W.C. 2,

July 15, 1918.

TESTING AIR COMPRESSORS.

TO THE EDITOR OF ENGINEERING.

SIR,—As an engineer, and one who for a good many years has been connected with compressors, especially for colliery work, I am much interested in the description and text published in yours of the 5th inst., of a Bellias and Morcom compressor, built to the instructions of Mr. N. S. Tennent.

The author distinctly states these tests were exhaustive and, no doubt, meant to be reliable, but to me, acquainted with the subject, other information is needed before reliance can be placed upon the figures as given.

Would the author kindly give the cylinder dimensions, stroke of piston and approximate clearance volume of first-stage cylinder; also state at what speed the machine was tested at—whether half or full speed? From these figures the volumetric efficiency could be found, and the results checked. Unless the above information is forthcoming, the text, as recorded, can have no interest or be of value to yours,

"AN ENGINEER."

July 10, 1918.

TIME RATES OF SHIPBUILDING IN AMERICA.

THERE has been received from America a detailed record of the work done day by day on the ss. Tuckahoe, which was built in 27 days. This is such a wonderful piece of work that we reproduce the figures in full.

Record of the ss. Tuckahoe, Collier, of 5,500 Tons Deadweight, recently built by the New York Shipbuilding Company, Camden, N.J., in 27 Days.

Schedule of Work.

	Tons.	Tons per Day.
April 8.		
104 shell plates	151	293
Centre-line keels on complete	30	
160 floors	112	
April 9.		
524 intercostal plates	58	76
37 floors	18	
April 10.		
10 shell plates	14	183
18 floors	12	
40 intercostal plates	5	
91 inner bottom plates	152	
April 11.		
16 shell plates	23	138
139 frames	71	
5 web frames	36	
Stringers Nos. 1, 2, 3, from bulkhead, Nos. 13 to frame No. 27	8	
April 12.		
26 shell plates	38	150
11 frames	6	
5 bulkheads	100	
Longitudinal bulkhead, 14 ft. 0½ in. from centre line between frames Nos. 55 to 61	6	
April 13.		
25 shell plates	37	88
40 side frames	20	
2 web frames	14	
3 inner bottom plates	5	
1 watertight peak bulkhead	2	
Gallery deck and beams complete	10	
April 14.		
15 shell plates	21	127
10 side frames	7	
81 main deck beams	49	
35 main deck plates	45	
Stringer No. 1, frames 111 to 126, P. and S.; Stringer No. 2, frames 98 to 111, P. and S.	5	
April 15.		
14 shell plates	20	109
Stern castings	11	
28 main deck beams	18	
Coal bunker bulkheads and flat	18	
Miscellaneous brackets under main deck; side plating of main deck plank	42	
April 16.		
Bilge keel, angle frame No. 50 to No. 90 P.; bilge keel, complete starboard	3	93*
10 shell plates	14	
Transom frame	4	
Watertight peak bulkhead	7	
38 frames	14	
30 main deck plates	40	
13 main deck beams	8	

* There are here 5 tons unaccounted for.

April 17.		
Bilge keel complete—port	2	77
Boiler-room casing	28	
Engine-room casing		
Swash plates in after peak	2	
1 main deck plate	1	
7 N.W.T. bulkheads on main deck at poop	10	
49 frames at poop	5	
20 shell plates	29	
April 18.		
12 shell plates	17	53
6 frames between main and poop decks	1	
Bulkhead at forward end of poop	5	
Cant frames	8	
Poop deck beams and plating complete	22	
April 19.		
23 shell plates	35	105
Channels on main deck trunk coamings	22	
Houses and rise bulkheads on poop deck	33	
Engine and boiler casing above poop deck	15	
April 20.		
15 shell plates	29	44
Port boss plate		
14 frames, forward	6	
Forepeak bulkhead	10	
4 breast hooks	1	
Chain locker and flat	7	
April 21.		
7 shell plates	9	45
6 frames at midship house	1	
2 bulkheads at midship house	10	
Bridge deck beams and plating complete	6	
Main deck beams Nos. 1 to 13	6	
Main deck plating, forward	13	
April 22.		
18 shell plates	26	131
Starboard boss plate	100	
Forecastle frame beams	3	
Stem	2	
Boilers shipped.		
April 23.		
6 shell plates	5	16
Bulkhead at end of forecastle	3	
Stringer No. 2 between steam and bulkhead No. 13	3	
Bulkheads on port side of pool for armoury	2	
Hatch coamings, except No. 1	3	
April 24.		
13 shell plates	17	39
Bulwark bkts.	5	
Channels at hatch No. 1	2	
Freeing ports	1	
Fo'castle deck plating	7	
Bulwark rails from frame 15 to 45, Nos. 73 to 91, port and starboard	4	
Stringer No. 1, stem to bulkhead 13	3	
Total	1,769	

The last 10 days before launching were occupied with fastening together parts, riveting, and finishing shell jobs. The Tuckahoe was launched with engines shipped and funnel and masts fitted, on May 5, 1918. She could have been launched two or three days earlier.

SELF-CONTAINED FORCED-DRAUGHT STOKER.

CONSTRUCTED BY THE UNDERFEED STOKER COMPANY, LIMITED, ENGINEERS, LONDON.

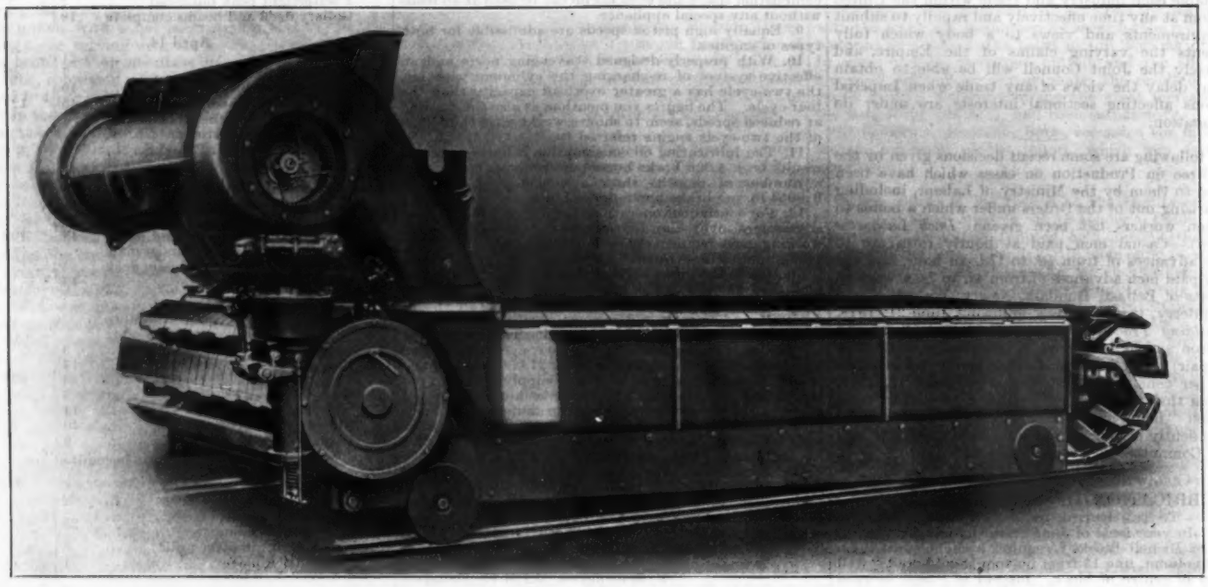


FIG. 1.

Fig. 2.

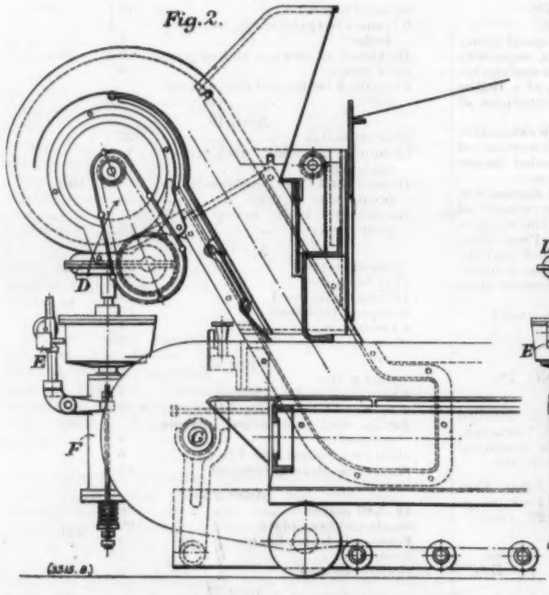
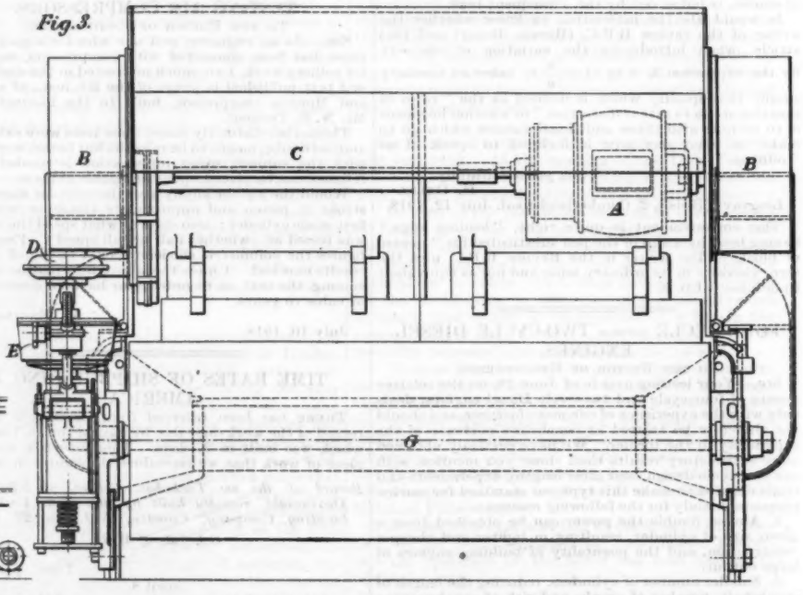


Fig. 3.



THE forced-draught stoker of the Underfeed Stoker Company, of Coventry House, South Place, London, E.C. 2, is too well known to need detailed description as to its general features. It has, however, recently undergone modification to render it self-contained, and at the same time to reduce the amount of power required to drive it. Briefly, the alteration consists in fitting an electric motor and fans directly to the stoker, so that there is no loss of power either in the transmission or in the air trunks. Hitherto the fans have been separate from the stokers, and the airways have caused loss of pressure in addition to occupying a good deal of space. Shafting has also been necessary for driving the moving firebars.

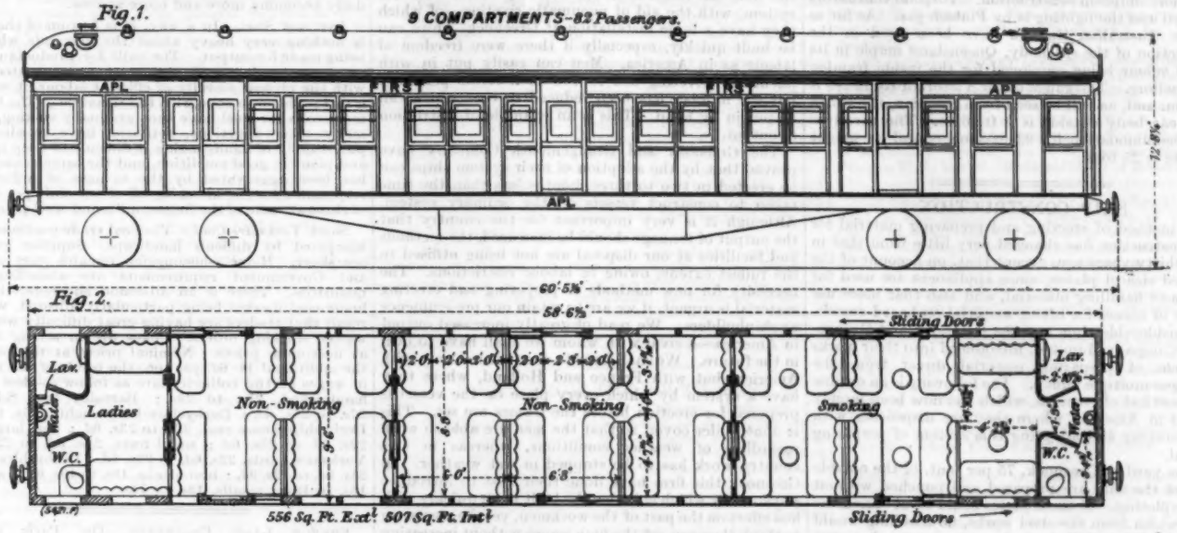
The new arrangement is seen in the engravings on this page, and it will be realised that it is exceedingly compact and free from complication. The electric motor A, Fig. 3, supplies the power both for the two fans B, B, and also for the chain grate, the fans being mounted on extensions of its spindle to right and left. At one end of the shaft is a sprocket wheel carrying a silent chain, which drives a shaft upon which is a worm in the casing D. This worm gears into a wheel on a vertical shaft, in connection with which there is a change-speed gear in the case E. Below this gear there is another vertical shaft fitted with a worm gearing into the main worm on the shaft G, Fig. 3. The shaft C carrying the fans runs at 950 r.p.m. to 1,050 r.p.m., and the worm in the case D at 330 revolutions. The worm wheel in D revolves the main stoker wheel at 1½ r.p.m. to 10 r.p.m., through the change-speed gear, which allows of eight variations. All the gearing is in dust-proof casings filled with oil.

The makers state definitely that with coal of 11,000 British thermal units this stoker, when applied to a modern type of boiler, will absorb only one-third of one per cent. of the power generated by the boiler. This is a very low percentage and represents a high efficiency.

CO-OPERATION IN TRANSPORT.—The Road Transport Board are endeavouring to secure the fullest economy in the use of petrol and of horses and horse fodder. For this purpose they are taking steps in various districts to bring about schemes of co-operation in delivery. As indicated in the Circular R. 167 of December 17 last, it is important that tribunals should do all that they can to encourage general co-operation among traders; and in this connection co-operation in delivery is often an important factor. In this matter, therefore, the tribunals and the local representatives of the Road Transport Board should work closely together. The Divisional Road Transport Officers and the Secretaries of the Area Road Transport Committees working under them will always be prepared to help in any scheme for the pooling of road transport facilities; and tribunals should, therefore, get into touch with them at the earliest stage of any scheme of this kind. Furthermore, the tribunals would do well to ascertain from these officers particulars of any schemes which are in contemplation, because these schemes may be of material assistance to the tribunals in deciding cases and in furthering arrangements for general co-operation. Tribunals would do well to urge on traders, in appropriate cases which come before them, the advisability of at once establishing schemes for preventing overlapping and waste in delivery because such schemes, if not now adopted voluntarily, may have to be compulsorily established under the powers vested in the Road Transport Board.

SALOON CAR FOR SPECIAL TRAFFIC ON THE VICTORIAN RAILWAYS.

CONSTRUCTED AT THE GOVERNMENT RAILWAY WORKS, NEWPORT, VICTORIA, FROM THE DESIGNS OF MR. W. M. SHANNON, M.INST.C.E., CHIEF MECHANICAL ENGINEER, VICTORIAN GOVERNMENT RAILWAYS.



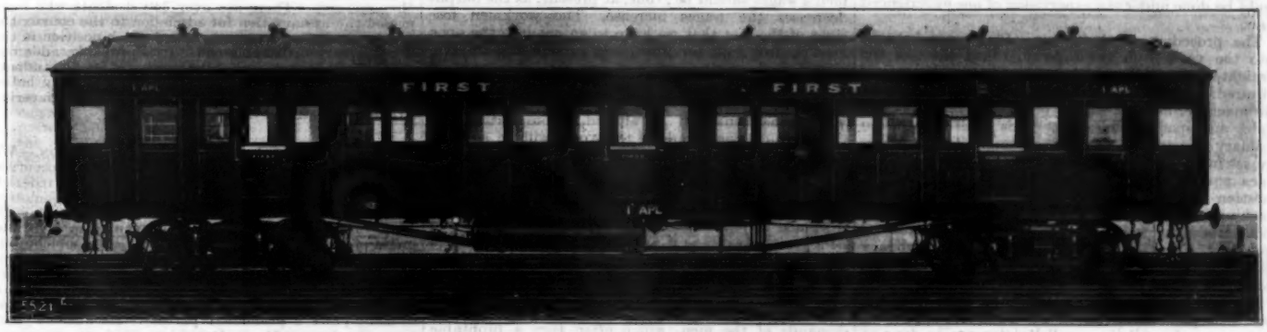


FIG. 3.

FIG. 4.

WE illustrate on the present page a type of saloon car for excursion and special traffic which has recently been introduced on the Victorian Government Railways to meet the requirements arising from the electrification of the Melbourne suburban lines. When this electrification is in full operation it will not be practicable, owing to the electrical equipment and the change in the method of lighting, to continue the use of the present suburban cars for country special and excursion traffic, and under these circumstances the Railway Commissioners arranged for the construction of suitable cars for this service. The necessary designs were therefore got out by Mr. W. M. Shannon, the chief mechanical engineer of the Victorian Railways, and the annexed illustrations show a pattern car of this new type which has recently been built at the Government Railway Workshops at Newport.

The car consists of a new pattern of body mounted on the under frame of one of the existing type of swing-door bogie cars. The last-named cars will be in future used as motor coaches, being fitted with new underframes and bogies of similar design to those built for the new sliding-door cars. By this plan the old underframes and bogies which are unsuitable for the electrical fitted cars are utilised, and cars of an excellent type for the desired service will be obtained at a cost of about 1,000*l.*, as compared with some 1,800*l.*, which would be the cost of a wholly new car.

The side elevation and plan, Figs. 1 and 2, show clearly the arrangement of the compartments of the new car, while Figs. 3 and 4 show the general appearance and the character of the internal fittings. In view of the car being intended for longer journeys than the ordinary cars for suburban traffic the number of doors has been reduced to one on each side of each of the three main saloons. The doors are of the sliding type, and they as well as the steel panels, seats, passage ways, partitions, &c., are of the standard patterns used on

the Victorian Railways. The seats, we may add, have been made as high as comfort will allow so as to enable some luggage and packages to be stowed beneath them.

The roof of the body is of the elliptical type instead of being of the clerestory form hitherto adopted on the Victorian Railways, thus giving an airy car and being more simple in construction. Torpedo ventilators are fitted and the lighting is by Pintsch gas. As far as possible Australian timbers have been used in the construction of the car body, Queensland maple in its natural colour being employed for the inside framing and panelling. The gauge of the Victorian Railways is 5 ft. 3 in. and, as will be seen from the plan, the width of the car body outside is 9 ft. 6 in. The car gives good accommodation for 82 passengers and its weight complete is 25 tons.

SHIP CONSTRUCTION.

THE method of erecting and preparing material for ship construction has changed very little from that in vogue thirty years ago, except that, on account of the increased size of plates, more appliances are used for lifting and handling material, and also that more use is made of cranes for lifting material on board vessels.

A considerable time ago the Greenock and Grangemouth Company, Limited, introduced into their works a system of preparing material direct from the De Bergue multiple punch. The following is an outline of the method of erection, which has now been largely adopted in America, where they are dispensing with mould-making and adopting this system of preparing material.

In the yard at Greenock, 75 per cent. of the outside plates of the ship are prepared and punched without any templating. If these plates could be obtained the proper width from the steel works, no handling would be required by skilled workmen, except when the plates were being screwed up in place. Even this work could be done under the supervision of one experienced man.

The procedure is as follows: Plates are brought into the yard from the railway, rolled through the straightening machine and put in piles until they are required. The plates are then taken in rotation to the machine, marked with a batten the length of the plates and spacing of frames. This is all done off an ordinary expansion plan of plating. The punches are set in the machine to suit the right spacing of the holes required for the particular part of the ship. The question of the spacing of the rivet holes to suit the machine has been raised with the classification societies, and permission was given to make the alterations necessary to suit either longitudinal or ordinary transverse work. The changing of punches is therefore reduced to a minimum.

The firm order as many plates of the one length and breadth as possible, so that time is saved when punching is commenced. All the parallel plates can be done at one shift. They are then lifted from the multiple punch by an hydraulic crane and landed at the scarphing machine. From thence they are removed to the vertical machine by the same crane. They are then countersunk and lifted by a crane to the planing machine. As they are all straightened, there is nothing to do but to take the plates direct to the building berth. The bottom shell plates are erected before there are any frames or floors put up. It is found more economical to put the shell plates up in place before any floors or frame shell longitudinals are erected. The floor plates and longitudinals are then lifted up and bolted to the shell plates. The bilge plates are punched from the multiple punch, set to the curve and erected immediately the floor plates are put up in place, thus completing all the bottom plating to the upper turn of the bilge before any of the frame legs are erected.

The tank top plates are punched immediately the bottom shell plates are finished, so that when the floors and longitudinals are fixed in place to the shell, the tank top plates are immediately put up and everything fixed in place. The bottom of the ship and tank top are thus plated in a very short time. Here, again, little or no templating or mould making is required. The tank top plates and side shell plates are finished so far as the automatic machine is concerned. Punching of the decks is commenced immediately, and they are prepared for erection as soon as the beams are put up. No ribbanding is necessary for the framing, shell or deck plates, the stringer plates bringing everything fair. All the plates are run parallel to the centre line and the edges of the plates up the side are treated as waterlines. There is a curve on the edge of plates at the end of the vessel only, so that by the adoption of this method the greater number of plates are punched by the machine. The firm have framed and fitted the side plating for 260 ft. of a 420-ft. vessel up to the sheer strake within eight days. They have not succeeded in doing this again, for the simple reason that their establishment is controlled by labour. They commence framing the vessel amidships (see illustrations, showing work in progress. on page 66), so that all the frames and midship shell plates are erected simultaneously and the centre part of the vessel is practically completed while the frame setters are setting the end frames of the ship, thus saving considerable time in construction, and shortening the time the vessel is on the building berth. On this system, with the aid of pneumatic riveting—of which they have a large installation at Greenock—ships can be built quickly, especially if there were freedom of labour as in America. Men can easily put in with pneumatic riveting 600 to 700 shell rivets per day; but the number has been reduced to that which can be put in by hand. This is an example of restriction of output.

The Greenock and Grangemouth Company have proved that by the adoption of their system ships can be erected in two to three months less than the time taken to construct vessels on the ordinary system. Although it is very important for the country that the output of tonnage should be increased, the methods and facilities at our disposal are not being utilised to the fullest extent, owing to labour restrictions. The necessity for new methods of preparing and erecting material is urgent, if we are to retain our pre-eminence as shipbuilders. We read of greatly increased output in America—a rival with whom we shall have to deal in the future. We shall have to compete not only with America, but with France and Holland, where they have a system by which every plate on the vessel is prepared for erection before the frames are set. This is done under cover, so that the men are able to work regardless of weather conditions, whereas in this country work has to be stopped in wet weather. In Greenock this firm have done their best to introduce a system by which ships can be built more quickly with less effort on the part of the workmen, yet the men seem to think they can get the high wages without increasing the output. The greater the output is, the higher the men's wages should be; but, at present, as the output decreases the wages increase. The workmen lose sight of the fact that we have to go out into the open market and look for work. At present the Government is the sole customer of the shipyards, a situation which cannot continue at the conclusion of the war. When private owners have to be dealt with, conditions will be altered. Competition for the cargo-carrying trade of the world will be so keen that owners will naturally purchase their ships where they can obtain them at the lowest price; whether it be in a British, Japanese or American shipyard, hence the necessity for shipbuilders and workmen to join hands and work together. It would be a great advantage if wages could be arranged for a period of years, so that when making contracts, builders would know that the work would be finished at the rates at which the contract was based. This, we believe, would be one way of overcoming the ever-recurring demands of the men, which often turn a profitable contract into one of loss. By fixing a rate for a number of years, both parties would be protected against the fluctuation of prices. As it is, no sooner is a contract made, than demands for increases are made over and above the rate on which the contract was based; therefore the loss is entirely on the employer.

UNIVERSITY COLLEGE, LONDON.—The following awards have been made in the Faculty of Engineering at University College: Archibald P. Head medal and prize, W. G. Heatly; Jews' commemoration scholarship, E. F. Anderson; Engineering diplomas: mechanical, M. Bindler; civil and municipal, F. Gutierres; civil and municipal (special distinction), W. G. Heatly; civil and municipal, J. Leech. A Goldsmid entrance scholarship, tenable in the Faculty of Engineering at University College, value 30*l.* a year for three years, may be awarded in September. Entry forms must be sent in on or before September 10.

CONTROL OF TIMBER.—By the Timber Order, 1918, dated the 16th inst., the Board of Trade have prepared for the introduction of a rationing scheme for imported softwood timber which will commence on the 22nd inst. A schedule of maximum prices for imported timber will be issued, but will not apply to existing stocks, which will still be subject to the previous regulations as to price. Stocks which under previous regulations may not be sold at prices above those ruling at January 31, 1917, are to be notified to the Controller of Timber Supplies for his decision as to the price at which they may be sold. The permit system is extended to home-grown converted timber on lines somewhat similar to those which have for over a year applied to imported softwood. Other matters dealt with include the position of timber on estates which are about to be sold, also sales of timber by auction and by tender. The Order is published in full in *The Board of Trade Journal*, and will also appear in *The London Gazette*. Particulars as to the new form of application for permits for home-grown or imported timber have already appeared in the timber press, and may be had on application to the Controller of Timber Supplies, Branch 2, at 80, Newman-street, Oxford-street, London, W. 1.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Employment Disturbed.—Industrial life is very slowly disengaging itself from the toils of the influenza epidemic, and since last week there has been very little improvement in the number of men at work. At the same time, the recruiting machine is relentlessly encroaching upon the works, and in all sections of industry the position is daily becoming more and more serious.

Iron and Steel.—In a way, it is fortunate that there is nothing very heavy about the demands which are being made for output. The calls for products undergo no change, and, indeed, if they were accentuated at all, with the present scarcity of efficient labour, it would be a real problem to cope with the situation. The Government calls for steel have been gradually sinking, and in many other directions, activities have receded. The poor supply of hands makes it difficult to keep furnaces and plant in good condition, and the same cause, which has been aggravated by the ravages of influenza, is responsible for the knocking off of one shift per day out of three at some of the forges, mills and steel plants.

South Yorkshire Coal.—The coal trade continues to be hampered by difficult handicaps. Supplies generally are short. Home consumption remains very marked, and Government requirements are absorbing large quantities. There is an all-round shortage, the local house-coal market being particularly affected, with the result that traders are having great difficulty with their winter stocking orders. Cokes are in strong demand at maximum prices. Nominal prices at the pit, with the additional 1*s.* 6*d.* per ton, the result of the increase in wages at the collieries, are as follow:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

FRENCH LADY ENGINEERS.—The Paris journal, *Le Génie Civil*, gives the list of the new students for the engineering school, the Ecole Centrale des Arts et Manufactures. There are over 340 students who have passed the examination for admission to the course, the number including six young ladies whose position in the list is a very favourable one. It is probable, adds our French contemporary, that the number of female students will increase in following years, and that young ladies having the required inclination will find in engineering situations worthy of their merits.

THE LATE MR. JOHN FREDERICK ROBINSON.—We regret to have to announce the death, which occurred at Inverness, on the 12th inst., of Mr. John Frederick Robinson, J.P., director of the North British Locomotive Company, Limited. Mr. Robinson was born on May 27, 1853. He passed the three years' course in civil and mechanical engineering at Owens College, Manchester, from 1869 to 1872, and then served three years' apprenticeship, from 1872 to 1875, with Messrs. Sharp, Stewart and Co., Limited, locomotive builders, Manchester, a firm with which his father, Mr. John Robinson, was for so many years a prominent partner. He was one year, from October, 1875, to December, 1876, at the works of the London and North-Western Railway, Crewe; and one year, from February, 1877, to March, 1878, at the Baldwin Locomotive Works, Philadelphia. In 1881 he became one of the managing directors of Messrs. Sharp, Stewart and Co., Limited, Manchester, and on the removal of their works to Glasgow—the Atlas Works—in January, 1888, he became sole managing director. Later, Mr. Robinson was appointed director of the North British Locomotive Company, Limited, which position he held at the time of his death. He was a member of the Institution of Civil Engineers since January, 1896, and since 1878 a member of the Institution of Mechanical Engineers. He was a member of the Council of the last-named Institution during the period 1902 to 1909.

THE ASSOCIATION OF BRITISH MOTOR AND ALLIED MANUFACTURERS, LIMITED.—Mr. Edward Manville was the guest of the evening at a dinner given by the Association of British Motor and Allied Manufacturers at the Royal Automobile Club on Wednesday, July 10. Mr. Manville, in addition to his numerous other important services to the motor industry, has until recently served as president of the Association of British Motor and Allied Manufacturers. He has recently been appointed president of the Association of Chambers of Commerce of Great Britain. Mr. H. C. B. Underdown, the new president of the association, said that the motor industry was entitled to a considerable degree of support from the Government. The recently-issued report of Lord Balfour of Burleigh's Committee showed a welcome recognition of this. He wished to sound a note of warning. On all sides one heard the cry for large outputs and a high degree of standardisation. Both were desirable, but they must not sacrifice quality to quantity. It was quality of manufacture which had made the British motor industry what it was. Mr. Manville in his reply drew attention to the youth of the industry, and its early and successful efforts to organise itself. The general mental attitude was now fluid. There should not be the same difficulty as there was in the past in convincing people of the need of changing their methods. There should, therefore, be an immense demand for motor vehicles, especially with a view to the increase in efficiency of transport and business methods.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Unprecedented activity marked the days immediately preceding the annual Fair Holidays, and when the steel works closed down on Thursday the number of orders which had been completed and turned out was highly gratifying, and this notwithstanding the many drawbacks with which makers have to contend at the present time. The general impression is that work will be resumed on Monday next, the 22nd inst., but this will greatly depend upon whether the requisite supplies of coal are forthcoming or not. In no direction has the recent shortage of coal been more acutely felt than in the steel-making establishments in the West of Scotland, and the Fifeshire pits have been called upon to make up the deficiency caused by the Lanarkshire pits being unable to meet the extensive demand. Should the miners return to work this week all will be well, but if they remain on holiday until Monday there is little chance of the steel workers resuming on that day. This contingency will no doubt be awkward as, despite the large output of the past few weeks, a very considerable tonnage is still on hand, for orders both for Government and the Admiralty are as plentiful as ever, and on this occasion it was absolutely impossible to get everything cleared off before the holidays. Ship and tank plates have been a heavy item, while both for the shipbuilding yards and the general engineering works sectional material has been greatly in demand. Fortunately, the recent high pressure has made the accumulation of stock once more possible so that should any unforeseen emergency arise during the time that the workers are on holiday there is something to fall back upon.

Malleable Iron Trade.—Last week was a particularly busy one in the malleable iron industry, a special effort being made, both in the iron and the steel departments, to rush through a good output, as practically no deliveries of certain sizes can be guaranteed until the early days of next month. Everything produced goes straight to the home consumer, for, despite the fact that there is a certain improvement in connection with shipping, no stocks are yet available for export. There is every expectation that the recent activity will continue for some considerable time to come.

Scotch Pig-Iron Trade.—The Fair Holidays which release the many thousands of industrial workers in Glasgow and the immediate neighbourhood, make no respite for the iron smelters; their task must go on as usual, provided, of course, that a sufficient supply of coal be available. All grades of pig-iron, and more especially hematite, are in constant demand for home consumption on work of national importance, so that nothing can be spared for export, no matter how pressing the claim, with the exception of some small shipments required by the Allied Governments. Foundry quality is not any more plentiful than it has been for some time past. While the iron and steel works remain closed it should be possible for the smelters to make some headway with arrears.

Clyde Trust Engineers.—Mr. P. D. Donald, for the past five years chief assistant engineer of the Clyde Navigation Trust, has been recommended by the New Works Committee to fill the position of chief engineer in succession to Mr. William M. Alston, who has just retired. During his fifteen years' service in the Clyde Trust, Mr. Donald has been associated with many important forward movements, and is well acquainted with the requirements of the onerous post.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The anticipated advance in export prices of pig-iron has been sanctioned, but disappointment is felt that no announcement has been made with regard to advances for home consumption. As was expected, prices are made retrospective, a circumstance which is a source of great embarrassment to traders. Merchants intimate that they have this week received notice from makers to the effect that the controller of iron and steel production had authorised an increase of 5*s.* on basic and Cleveland pig-iron for export for all deliveries from April 1 last, and that arrangements had been made with the Ministry to charge 1*s.*—representing the increased wages—for basic, and Cleveland pig-iron shipped between December 1, 1917, and March 31, 1918. Thus the export quotations of No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all raised to 119*s.*, and No. 1 is advanced to 124*s.* Prices for home consumption are unaltered, No. 3 and the lower qualities remaining at 95*s.*, and No. 1 at 99*s.* Resumption of deliveries of Cleveland pig-iron to Scotland are reported for the restarting of work north of the Tweed after the holidays which come to an end on the 22nd inst. Cleveland foundry pig-iron is well taken up, but forge kind is quite plentiful, and in only very moderate request. Makers of the latter are eager to make sales on both early and forward account. Distribution of pig-iron would be heavier but for lack of labour, as trucks are fairly plentiful, and more tonnage is coming forward.

Output of Pig-Iron.—Production of pig-iron has been reduced by the blowing-out of a furnace which was running on Cleveland iron. The number of furnaces now in operation is 74, of which 32 are making Cleveland pig-iron, 22 are producing hematite, and 20 are manufacturing special kinds of iron.

Hematite Iron.—Production of East Coast hematite iron is well maintained, but the make is not quite sufficient to meet all needs. However, continued strict control of delivery enables all home essential requirements to be dealt with, and leaves fair quantities available for export. Prices are not changed, mixed Nos. standing at 122*s.* 6*d.* for home use and 147*s.* 6*d.* for shipment to the Allies.

Manufactured Iron and Steel.—The manufactured iron and steel industries are characterised by very great activity, with increasing pressure for delivery. The steady progress reported with extensions at works resulting in increase to output is gratifying, but the now huge, and still growing production is not sufficient to meet the enormous needs. A little more material is becoming available for shipment, but the bulk of the output is absorbed by the home needs of the Government either directly or indirectly. Prices are very strong. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; double best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.* steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* Export prices are not fixed, but approximately they may be given at 2*l.* to 3*l.* above home quotations.

Coke.—Demand for coke is unrelaxed, and it is altogether impossible to meet requirements. Absolute needs of the blast furnaces, however, continue to receive adequate attention. Permission to advance prices is anxiously awaited, and meanwhile average furnace quality remains at 33*s.* at the furnaces; and low phosphorus sort at 35*s.* 6*d.* at the furnaces.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Coal salesmen are still embarrassed by the shortage of pretty well all classes of coal, and are apprehensive of an aggravation of the present difficulties owing to the absence of men on their usual summer holidays. In the steam coal area absenteeism is not quite so bad this week, but the influenza epidemic among colliery workers has not by any means subsided so far. The supply is much below the requirements. Neutrals are receiving only such bare supplies as are requisite to obtain return cargoes essential to this country, while even shipments to France have been below the average. Practically nothing is now being released for ordinary trading account. The scarcity embraces all descriptions, but, of course, it is most acute in the case of large steams. Smalls are little better, but washed smalls are practically unobtainable. Interest in the coal market centres at the moment in the question of the revision of Admiralty coal prices. During the past few weeks all coals for inland consumption and for export have been increased 4*s.* per ton. The question is of particular interest to South Wales, as a very considerable proportion of the coal produced in that coalfield is at present being commandeered by the Admiralty at prices considerably below those scheduled, and while it is believed that the Admiralty prices will certainly be increased, it is not yet known by what amount.

Newport.—Hardly any private business is being arranged, and it has been found impracticable even to release coals for which pre-entry forms have been served weeks ago. The authorities are commandeering all the steam descriptions for naval and allied account, while munition works and public utility undertakings are receiving the major portion of inland supplies. Pitwood and iron ore have been in fair supply.

ELECTRICAL RESEARCH COMMITTEE.—The Electrical Research Committee which was appointed last autumn, under the auspices of the Department of Scientific and Industrial Research, is at present engaged in superintending a research on insulating materials (fibrous materials, porcelain, ebonite, mica, composite materials), and the waterproofing treatment of insulating windings of electrical machines, in respect of which grants have been made to the committee by the Research Department, the B.E.A.M.A., and the Institution. The committee consists of three members nominated by the Institution of Electrical Engineers and three members nominated by the British Electrical and Allied Manufacturers' Association, the nominees of the former being Mr. C. H. Wordingham, C.B.E. (chairman of the committee) Mr. C. C. Paterson, O.B.E., and Mr. C. P. Sparks, and, those of the latter Mr. F. R. Davenport, Mr. D. N. Dunlop, and Mr. A. R. Everest. The temporary address of the committee is No. 1, Albemarle-street, London. W. 1, and its secretary is Mr. P. F. Rowell.

GAS TRACTION.—The Gas Traction Committee (the Petroleum Executive, 12, Berkeley-street, W. 1) announce that the following arrangements have been made, pursuant to Section 17 of their interim report, in respect of the Metropolitan area: (1) The Commissioner of Police of the Metropolis has approved the issue of licences for 20 motor omnibuses equipped to run on compressed coal-gas; (2) the necessary authority has been obtained to conduct trials with 20 goods-carrying commercial motor vehicles equipped to run on compressed coal-gas; (3) the Petrol Control Department of the Board of Trade has sanctioned the issue in due course of the requisite gas permits; (4) the Coal Controller has concurred in respect of an agreed maximum total volume of gas on the understanding that the supply may have to be cut off during the winter months if the exigencies of the gas position demand this course. The committee has approved a request that it should provide a gas Traction Section at the British Scientific Products Exhibition, which is to be held in London next month under the auspices of the British Science Guild.

NOTICES OF MEETINGS.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Thursday, July 25, at 3 p.m., the annual general meeting of the Members of the Institute will be held at the University, St. George's Square, Sheffield. The following paper will be read:—"Some Notes on an Old Colliery Pumping Engine," by Mr. Gerald T. Newbould. The following paper will be open for discussion:—"Face Conveyers," by Mr. H. C. Jenkins.

THE ROYAL SANITARY INSTITUTE.—Saturday, July 27, at 11 a.m., in the Council Chamber, Town Hall, Ipswich. Discussions will take place on "Housing: from the Point of View of Economy in Planning and Construction," to be opened by Sir Henry Tanner, C.B., I.S.O., F.R.I.B.A. (who will preside at the meeting), and on "The Provisions of Maternity Homes," to be opened by Mr. A. M. N. Pringle, M.B., D.P.H. (Medical Officer of Health, Ipswich).

GUN SHOP MANAGEMENT.—Mr. A. Galbraith, formerly head of the Engineering Department of the Cunard Company, and therefore closely identified with the Cunard National Shell Factory, has now become more definitely associated with munition work on a large scale, having been appointed to the control of the Ordnance Department of Messrs. William Beardmore and Co., Naval Construction Works, Dalmuir.

CHEMISTS AND THE WAR.—The great nations engaged in the present war, says *La Technique Moderne*, have duly recognised the services rendered by chemistry and have granted to chemists a special status, except France. Germany has 30,000 chemists, the United States 16,000, Great Britain 5,000, and France 2,500 only; the first three nations have not one of these specialists in the firing line, whilst France has 400 still there.

THE ORGANISATION OF INDUSTRY.—A meeting of the Industrial Reconstruction Council will be held in the hall of the Institute of Journalists, 2 and 4, Tudor-street, E.C. 4, on Wednesday, the 24th inst., at 6 p.m., when Mr. Arthur Greenwood, Secretary to the Whitley Committee, will open a discussion on "The Organisation of Industry." In addition to members of the Council there will be present delegates from various trade unions and associations, and it is expected that an important debate will result.

ELECTRICAL TRADES DIRECTORY.—The Electrical Trades Directory and Handbook, for 1918, the thirty-sixth year of publication, is now available. It is issued by *The Electrician*, and is published by Messrs. Benn Brothers, Limited, 8, Bouverie-street, Fleet-street, E.C. 4, at the price of 15*s.* net. It opens with tables and technical data, digests of the laws of electric lighting and traction, regulations, wiring rules, working rules, duties, tariffs, &c., followed by directories of electrical companies and engineers in Great Britain, by name and trades, and ending with Colonial and foreign directories. The same editors and publishers have issued, at the price of 5*s.* net, their annual tables of electricity undertakings of the United Kingdom, the Colonies and foreign countries. The tables are arranged alphabetically according to town or district, the information given including the date when supply was commenced, the name of the company or corporation, the engineer, system, voltage, connection, fuel used, plant, price per unit, &c. Both productions have been carefully prepared and will prove most useful for reference purposes.

LOW-TEMPERATURE COAL CARBONISATION.—An extensive series of experiments on Carbocoal, a new low-temperature carbonisation product, has been carried out on a commercial scale during the last three years by the Malcolmson Briquet Engineering Company, of Irvington, New Jersey; the new coal has been tested during the last year on railways and in the United States Navy, and a very satisfactory recovery of by-products is claimed for the new process of Mr. Charles H. Smith, of the company named. The account of the experiments given in the May issue of the Bulletin of the American Institute of Mining Engineers, does not refer to costs. As two distillations are required, the first at 850 deg. F. or 900 deg. F., the second at 1,800 deg. F., the costs may be high. The primary distillation of the raw coal is a continuous operation, lasting one or two hours; the retort has a capacity of 1 ton of coal per hour, and the charge is moved by paddles at adjustable rates. The semi carbocoal leaving this retort is mixed with a certain proportion of pitch from previous operations and briquetted, the briquettes being submitted to the second distillation on benches; the benches are described, like the retorts, as vertical, inclined, or horizontal, but inclined, self charging and discharging benches seem to be preferred. The carbocoal is said to be dense, smokeless, and dustless, and grayish-black; being relatively soft, but tough, it burns readily, and requires little draught; high evaporation rates have been obtained, and it also makes a good house fuel; bricks are made in several sizes. Carbocoal has been manufactured from various sorts of coals. The total yield of tar of the process is large—30 gals. of water-free tar per short ton of coal: the tar contains a large percentage of light solvent oils, paraffins, benzol and toluol, tar acids and cresols, but very little carbolic acid and neither naphthalene nor anthracene. There is little ammonia in the first distillation product; the second distillation of the briquettes yields more ammonia, bringing the ammonium sulphate up to 21 lb. per short ton of coal carbonised. The semi-carbocoal represents about 72 per cent. of the coal charge, but contains nearly all the nitrogen, and is, therefore recommended for by-product gas producers.

THE CONSTRUCTION OF SHIPS WITH MULTIPLE PUNCHED PLATES.

THE GREENOCK AND GRANGEMOUTH DOCKYARD COMPANY, LIMITED, GREENOCK.

(*For Description, see Page 64.*)

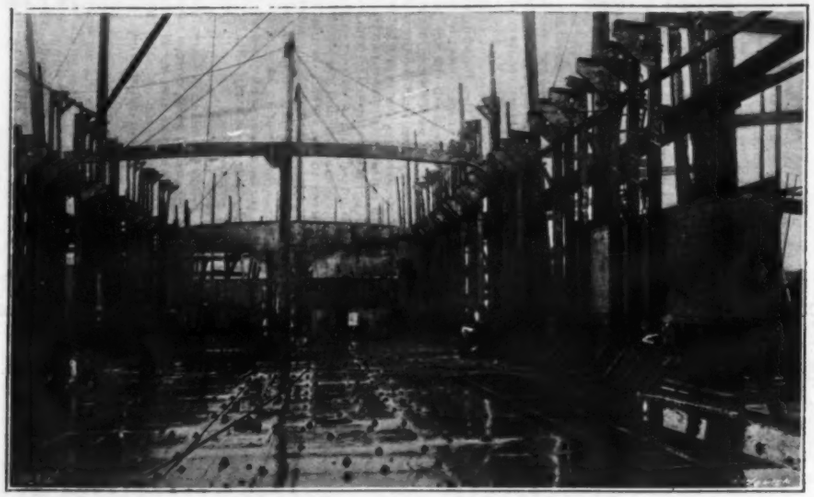


FIG. 1. MIDSHIP PORTION OF FRAMES ERECTED AND SHELL PLATES BEING PUT IN PLACE AT THE SAME TIME.

FIG. 2. INSIDE VIEW OF THE MIDSHIP PORTION OF THE VESSEL FRAMED AND SHELL PLATES BEING ERECTED; END FRAMES NOT YET SET.

FIG. 3. MIDSHIP PORTION OF FRAMES AND PLATING ERECTED; AFTER-END FRAMES NOT YET SET OR ERECTED.

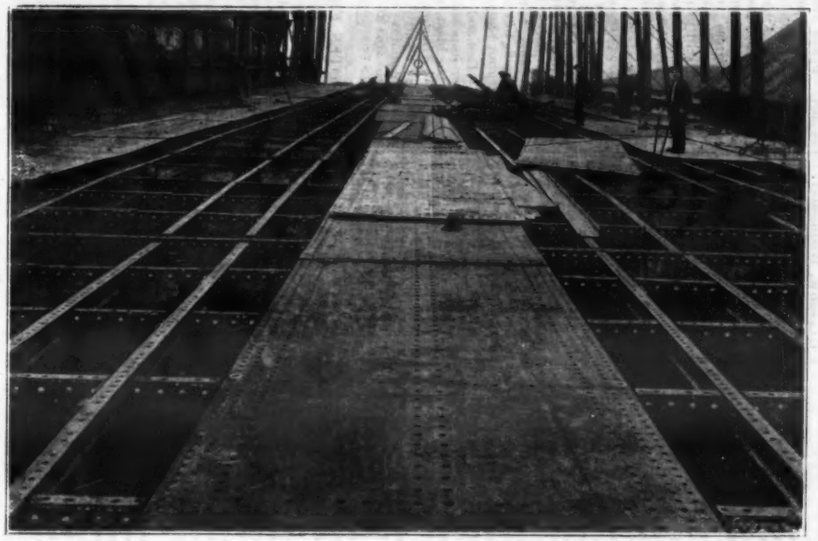
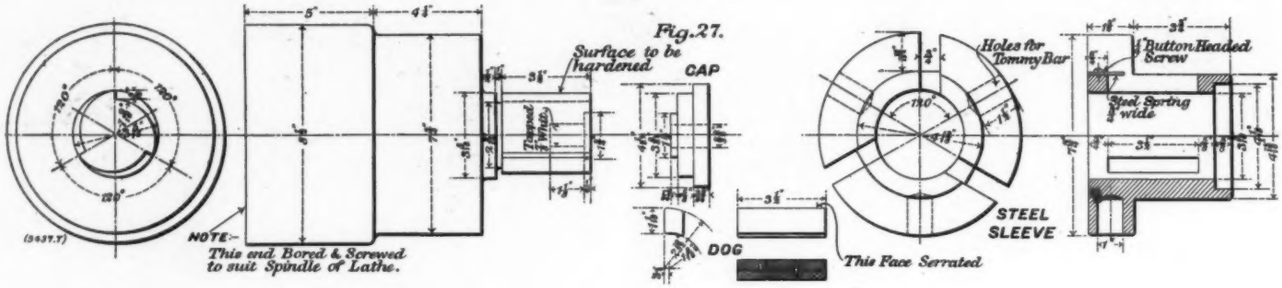


FIG. 4. TANK TOP AND PLATES FROM THE MULTIPLE PUNCH.

THE CUNARD NATIONAL SHELL FACTORY.

(For Description, see Page 57.)



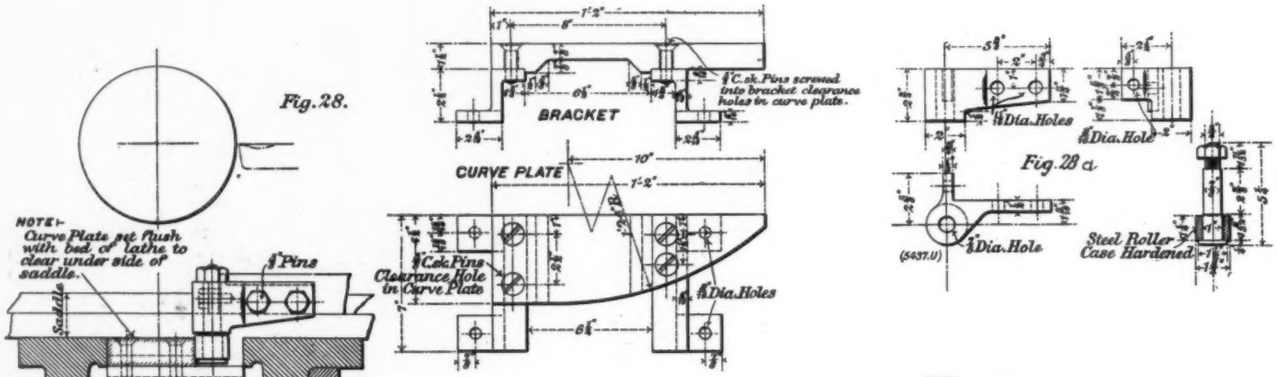


Fig.28.
BRACKET
CURVE PLATE
C.sk. Pins screwed into bracket clearance holes in curve plate.
NOTE:- Curve Plate set flush with bed of lathe to clear under side of saddle.
Saddle
¾ Pins
¾ C.sk. Pins
Clearance Hole in Curve Plate
¾ Dia. Holes
Fig.28a
¾ Dia. Holes
¾ Dia. Hole
Steel Roller Case Hardened
Fig.28b
NOTE:- To increase dia. of nose run the tool towards right or in direction of arrow.
Lathe Face Plate or Driving Plate
¾ Pin
NOTE:- W.I. Bracket & Roller fitted to side of Saddle next Face Plate.
PART PLAN
Saddle
Cen. L. of Lathe
Packing if necessary to clear saddle.
Horizontal distance between centre of roller & centre of nose of tool.

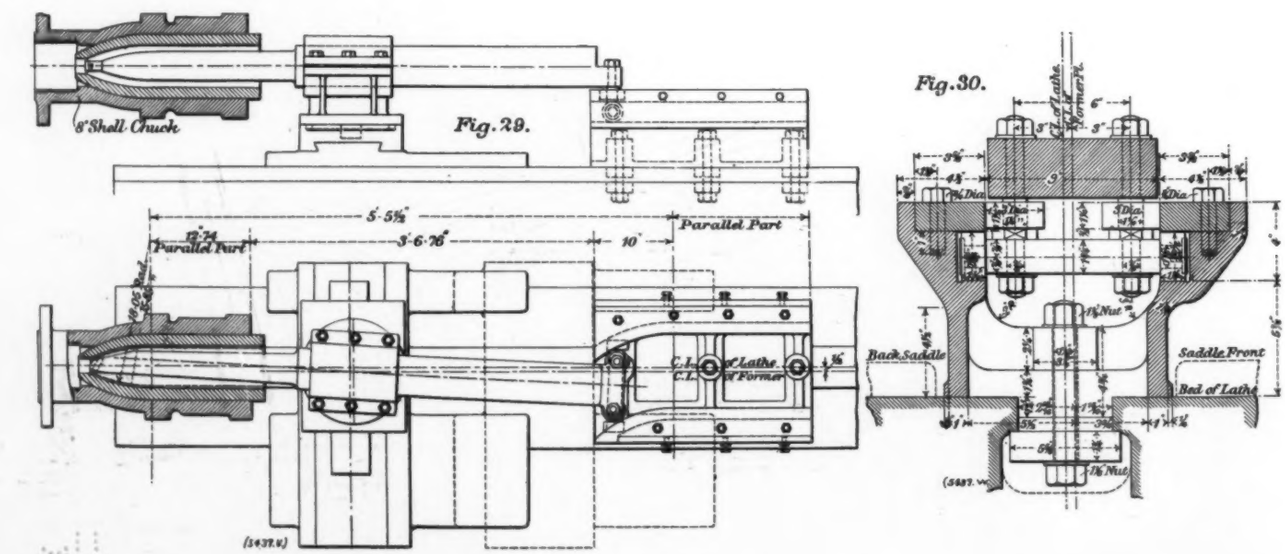
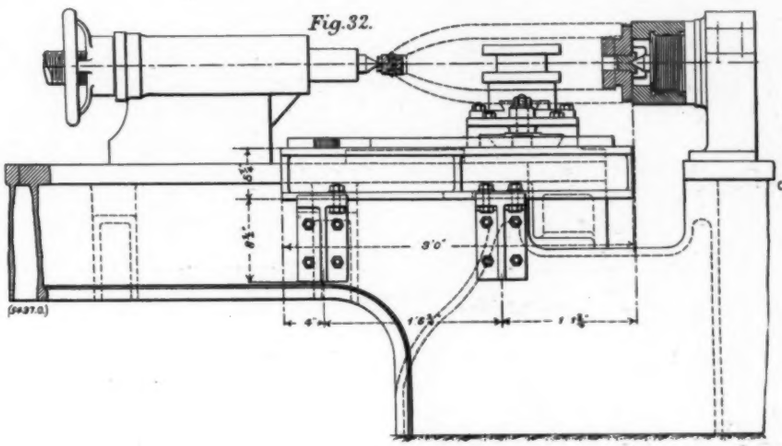
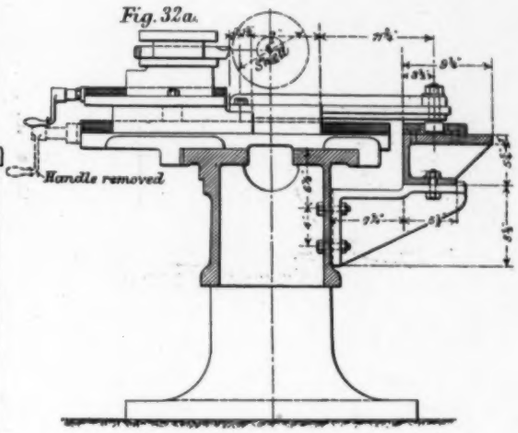


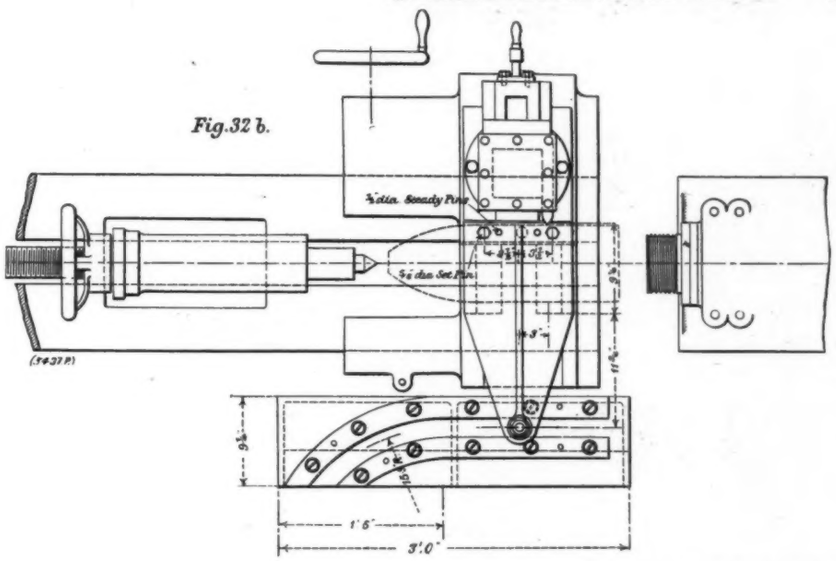
FIG. 27. DETAILS OF SCROLL CHUCK FOR ROUGH TURNING OPERATION ON 8-IN. SHELLS. FIGS. 28, 28*a* AND 28*b*. CURVE PLATE FOR ROUGHING THE NOSE OF 8-IN. SHELLS. FIG. 29. INTERNAL BORING GEAR AS ATTACHED TO ORDINARY ENGINE LATHE. FIG. 30. FORMER PLATE FOR PROFILING THE BORE OF 8-IN. SHELLS.

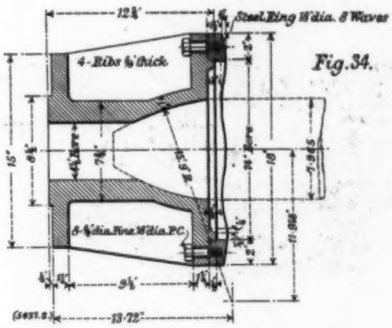
THE CUNARD NATIONAL SHELL FACTORY.

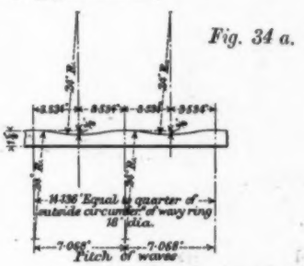
(For Description, see Page 57.)

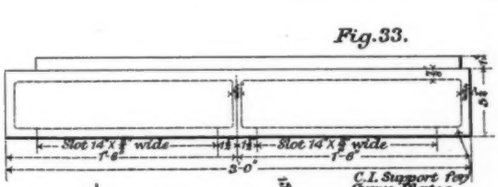


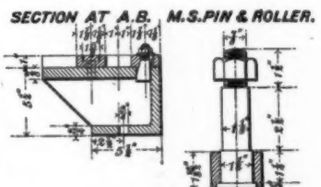


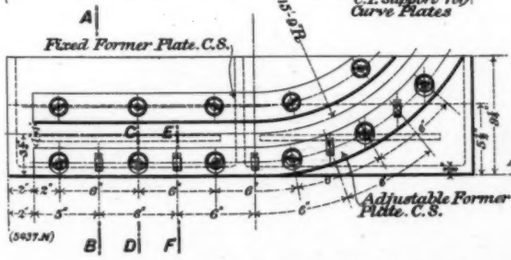


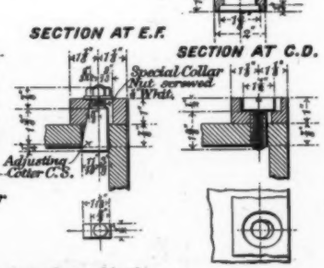


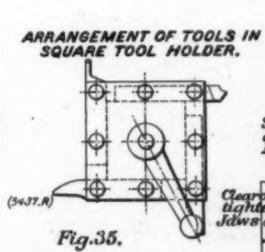


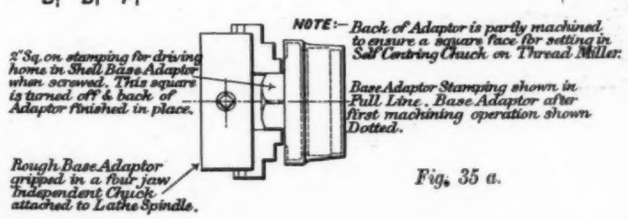









ARRANGEMENT OF TOOLS IN SQUARE TOOL HOLDER.
Self Centring Chuck attached to Thread Miller
Clearance for tightening Jdws of Chuck
Ring Edge
(5437.R)
Fig.35.


NOTE:- Back of Adaptor is partly machined to ensure a square face for setting in Self Centring Chuck on Thread Miller.
2" Sq. on stamping for driving home in Shell Base Adaptor when screwed. This square is turned off & back of Adaptor finished in place.
Base Adaptor Stamping shown in Full Line. Base Adaptor after first machining operation shown Dotted.
Rough Base Adaptor gripped in a four jaw Independent Chuck attached to Lathe Spindle.

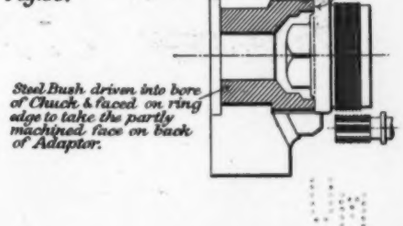


Fig. 35 a.

FIGS. 32, 32a AND 32b. COPY PLATE FOR PROFILING 8-IN. H. E. SHELLS; FIXED TO 10-IN. SWIFT LATHE. FIG. 33. ADJUSTABLE COPY PLATE FOR PROFILING 8-IN. SHELLS. FIGS. 34 AND 34a. CAST IRON CHUCK FOR TURNING WAVES ON 8-IN. SHELLS. FIGS. 35 AND 35a. METHOD OF MACHINING BASE ADAPTOR FOR 8-IN. SHELLS.

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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

SUBSCRIPTIONS, HOME AND FOREIGN.

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3063 and 8506 GERRARD.

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With Two One-Page Plates of the CUNARD NATIONAL SHELL FACTORY.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 3d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents after June 24th will not have copies for chance customers, therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 65.

ENGINEERING.

FRIDAY, JULY 19, 1918.

EDUCATION AND INDUSTRY.

THE passing of the Education Bill through the House of Commons, with the probability that before the month is out it will be approved by the House of Lords and placed on the Statute Book, is an event of far-reaching importance to industry. We have always contended for increased mentality in the factory, and at no time has this been more necessary than now, because of the increased rate of pay given practically to every class of worker. The only method of balancing accounts, from the labour as well as the national point of view, is to ensure a higher output for the week's earnings, and this can be done by bringing increased intellectual power to bear not only on the design of products, but on the mechanical methods of manufacture. Increased production for a given remuneration to labour and capital, in order to ensure a lower selling price, is essential if we are to have a balance in manufactures for export. Without this reduction in selling price we shall not be able to extend our foreign markets, so that the whole industrial situation demands an increased exercise of brain power.

The Education Bill tends in this direction, but much must necessarily depend on the Education Department of the Government, and perhaps even more on a closer co-operation between industry and the educational authorities. It is not sufficiently recognised that brain power is the greatest asset the nation possesses and that every child born is endowed with a brain. This is an immense potentiality from the productive point of view and in furthering the prosperity of the nation. But lest we may be misunderstood, let us thus early emphasize the view that industry does not demand the exclusive cultivation of the intelligence of each child for materialistic ends. Indeed, we hope that even in the continuation classes, or the vocational classes provided for in the Bill, something higher will be attempted than that which is dependent on the mere desire or capacity to make money. It is not inconsistent with material wealth to foster the development of the mental faculty along broad, liberal lines. On the contrary, the association of culture in its higher sense will assist industry, because it leads not only to a higher conception of life, but to the creation of an ability to take more out of life, thereby conducing to fuller attainment. Education in its broader sense should have as its main object the training of the mind towards the achievement of greater happiness, and this can only be got by developing the thinking faculty, so that a better perspective of life can be attained. Thereon rests the hope for greater amity between employer and worker and a higher realisation of the duties of citizenship.

It may be idealistic, but it is nevertheless desirable to aim at rendering all work a contribution to national prosperity, and in doing so to ensure that each contribution shall carry with it not only a higher remuneration, but a satisfaction in "something attempted, something done." Education has a duty towards industry, as well as being a most important factor in the broad culture of the individual. In the first place it is important that each individual shall be guided towards that trade or profession for which he is best suited and in following which he will realise the greatest pleasure. In the past the educational authorities have not concerned themselves in a systematic way or even indirectly, in guiding pupils towards the most desirable occupations. It would be well if the managers of works were more closely in contact with the head masters in their district. Co-operation, especially in the continuation classes, between education and industry, would enable a boy who had a bent to be still further inclined towards that trade or profession for which he is best suited; further, there would be openings ready, when he had been prepared, for taking up the vocational work in association with his apprentice work. In most provincial communities this unity of action between teacher and factory is comparatively simple, but in London the difficulties are great. We know from many teachers that a great number of London boys have the desire and the mental capacity to become engineers, but, owing to economic conditions—the high scale of rent, heavy taxation, the cost of living, and other reasons, engineering works have had to seek new sites in the country, and in the case of the sons of comparatively poor men it is difficult, if not impossible, to find the money requisite to maintain their boys in the provincial areas to which engineering firms have migrated. Would it not be possible for scholarships, either those already existing, or new ones to be created, to be devoted to helping such boys so that they might have a chance of entering the ranks of engineering and other important industries, rather than be left to find blind alley appointments, or at best to overcrowd the great army of clerks in the metropolitan area.

In the higher grades there is equal need for the co-operation of education and industry. The Bill undoubtedly opens a path with a great vista for the able youth, and it would be well if, here again, the number of scholarships could be increased, because assiduity and earnest exertion are more often associated with poverty than with wealth. There is a rich, but almost unworked vein of potential brain power in what are called the lower middle classes. National scholars in the past have tended to enter the Government service, but it would be a good thing if a large number of such scholarships were allocated to those whose future was to be spent among the great army of industry. In this we are sure the Government would have the co-operation of all enlightened employers of labour, and we are certain that industry would enormously gain from the accession of highly trained youths, intent on making a place for themselves in the manufacturing world. No doubt much has been done already, and that is a great gain; but it only accentuates further the necessity for a well-organised scheme for the higher training of those of the humbler classes who have great promise.

The services of the students in advanced technical schools could, even during their training, be very advantageously utilised in conducting the apprentice classes. Their time, too, would be well spent in such work, in illustration of which we may quote the familiar saying that teachers by teaching learn themselves. Apart from this, we conceive some difficulty in obtaining masters with sufficient technical knowledge, still more of obtaining men with sufficient practical experience able to transmit their knowledge and experience to the inquiring student. Unfortunately there has been a tendency in many works to advance to the rank of foreman, and even works manager, men who, however wide their practical knowledge, have suffered from their long association with the uncultured classes; and such men will fail to create in the class-room that atmosphere which is essential, not only to the development of technical knowledge, but still more to the inculcation of those broad principles of conduct in life so desirable in the men who will ultimately become the officers of the industrial army. It were well, therefore, that as soon as possible after the

war, men should be assisted, either by way of scholarship or otherwise, to combine technical knowledge with practical experience, so that they may fill the breach now existent in the national staff of teachers. Many of the officers who have been through the severe ordeal of battle will, no doubt, come back with the broad outlook and intense sympathy which are good sources for the development of the right atmosphere; and many of these in their lives during peace had acquired the requisite technical qualifications to justify their promotion to scholarships and as teachers in works classes. No better reward, or more suitable outlook, could be conceived than their promotion as subalterns in this more highly trained industrial army.

There is one more phase of the subject which is of vital consequence. We require not only a greater number of scholarships, but others of far greater value. The tendency in education, particularly in the past, is towards a general level. In earlier days this was inevitable, but as soon as there emerges from the common stock the lad of parts, the educational authorities should concentrate a greater measure of attention on such exceptions. This should continue through the successive years or stages of education, until it can be said that there is no brain in the land—irrespective of the origin, however humble, of the possessor—that has not been cultivated to its full capacity. Consequently it is necessary that there should be more scholarships of considerable value, so that such men, without having anxiety as to material affairs, can conduct researches on any given subject to a final conclusion—as final as is possible in our present state of incomplete knowledge.

CANADIAN STEEL, ENGINEERING AND SHIPBUILDING INDUSTRIES.

THE progress, position and prospects of the steel group of trades in Canada are striking. Last year the Dominion—the Empire's greatest food producer—actually exported manufactures of a larger value than agricultural produce. And most of the manufactured exports were in the steel line. Yet it is less than twenty years since one of the greatest authorities declared that Canada's iron and steel-making resources were poor, and the prospects not bright. It is more than a hundred years since iron-making was first started in the Dominion, but little success was met with until quite recently. None of the early enterprises were profitable. Some of them were financially disastrous. One concern carried on twenty years without a dividend. Even after the Dominion Government began to pay bounties on iron and steel production, in 1884, little success was attained until the twentieth century set in. The Steel Company of Canada, Londonderry, Nova Scotia, for example, was formed in 1873, and built two large blast furnaces, several steel melters and a mill, and manufactured castings wheels, rails, rolls, and many special products, but eventually the concern had to be wound up. No further attempt on a large scale was made until the Dominion Iron and Steel Company was formed in 1899. This enterprise began by smelting Newfoundland ore at Sydney, Cape Breton, and making pig-iron, steel, billets, rails, plates, &c. Even this modern concern has had a chequered career until quite recent years. But now there are several large and successful iron, steel, engineering, and even shipbuilding companies in Canada.

As recently as 1910 Canada imported over 1,000,000 tons of iron and steel, valued at 57,000,000 dols., of which no less than 46,000,000 dols.' worth was from the United States. At one time British products held almost a monopoly in the Canadian market; but when the stee trade of the United States assumed large dimensions geographical considerations counted, and British trade lost ground. Now the Dominion is exporting on a large scale, as may be gathered from the fact that last year she sent out 56,000,000*l.* worth of "cartridges and other explosives," 9,753,000*l.* of other "iron and steel and manufactures thereof," 2,880,000*l.* of "automobiles and other carriages," 270,000*l.* worth of electrical apparatus. There are now 700 factories in Canada producing munitions of war, and they employ over 750,000 men. There are over 200 steel furnaces and converters of various descriptions, of which about 30 are electric furnaces of the very latest types. The largest of the Canadian firms is making pig-iron at the rate of 350,000 tons a year, steel ingots 600,000 tons, and finished products at the rate of 300,000 tons. The higher branches of engineering are making rapid headway.

The Dominion Government has this year completed arrangements with the Dominion Iron and Steel Company, of Sydney, for the erection of a steel plate rolling mill with an annual capacity of 150,000 tons, to be devoted exclusively to shipbuilding requirements. It is expected that this will be in operation before the end of the year. At present plates are being obtained from the United States. The total shipbuilding capacity of Canada is now estimated at 250,000 tons a year. The Munitions Board had contracted for the building of 37 steel steamers ranging from 3,500 tons to 8,800 tons up to the end of last year. At least a dozen yards of modern design and considerable dimensions will be in operation by the end of this year, besides several smaller ones for the building of wooden vessels. At the present moment nearly 30 steamers are under construction, the largest, of over 8,000 tons, at the yard of Vickers, Limited, at Montreal. A vessel of 8,800 tons deadweight has already been launched at Vancouver. This is the first of 8 which are being built to the order of the British Government. The Munitions Board has also placed contracts for 46 wooden vessels, aggregating 128,000 tons, and 43 steel ships of an aggregate of 211,000 tons, in addition to those ordered before the end of last year. Thus, after many ups and downs, the Canadian iron, steel and engineering group of industries seem firmly established.

It has long been well known that the coal reserves of Canada are practically inexhaustible, and the mineral is of good class. About 15,000,000 tons of coal was mined last year. But owing to the big demand, coupled with shortage of mining labour, more than 20,000,000 tons was imported, chiefly from the United States.

Iron ores are also now known to abound in practically every province, whilst the deposits in the neighbouring Colony of Newfoundland are both huge and rich. About four-fifths of the ore consumed in Canadian blast furnaces are from Newfoundland. But recent investigations by the Department of Mines indicates that Canada itself is exceedingly rich in iron ores.

SOURCES OF POTASH.

THE problem of utilising the various natural sources of potash which do not yield their potash to simple, direct methods of treatment, is receiving earnest attention, especially in the United States. The movement owes its impetus to the war, of course, though with the development of modern high explosives the needs of potash for ammunition purposes have not grown in any noteworthy proportion. The days of black, potassium nitrate gunpowder are gone, and the amount of potassium chlorate wanted for primers, &c., does not represent more than a few per cent. of the total demand for potash. It is the general interference of the war with international commerce which has made the potash question acute. When the American Institute of Mining Engineers and the American Electrochemical Society discussed "Potash" in a joint meeting last January, Colonel Cushman stated, that the United States were, in 1914, using 300,000 tons of potash. The demand for potash was then rapidly increasing, and it was estimated that the demand would have risen to 500,000 tons in 1917, even if there had been no war. Some 8,000 tons of potash were actually produced in the country in 1916, scratched up from all sources, as Dr. Cushman expressed it; that figure was probably doubled in 1917. These figures must not be taken as a measure for the activity in the field. A large number of works are investigating the potash problem on a technical scale. The recovery of potash from dust and fumes plays an important part in these investigations, and even if, with the return of normal conditions, some of the potash recovery processes under trial should be abandoned as not profitable, industry as a whole can only profit from researches aiming at the suppression of waste and nuisances as well as at utilising new raw materials. We have repeatedly referred to the potash problem of late. But matters are advancing, and the statements made at the meeting mentioned, notably also by Dr. William H. Ross, of the Bureau of Soils, and other recent communications will help us to review the whole problem. It is to be understood that we shall only deal with the minor sources of potash.

The most ancient method of producing potash, namely, by leaching the ashes of hard wood, no longer counts, except in remote forest districts, where this source of the alkali may still suffice for the local production of soap. The kelp industry, equally ancient possibly, is carried on at the Pacific Coast on more systematic lines than in Scotland and Ireland. Nine companies were engaged in this industry on the coast of California in 1917. One of the most important of these companies, the Hercules Powder Company, leaches the kelp without drying it, recovering the solvent acetone; the other, the Diamond Match Company, first chars the kelp; none of the other seven companies refine their potash by crystallisation, and practically they only produce fertilisers. The total potash production from kelp amounted to 1,556 tons in 1916 and to less than 5,000 tons in 1917. With that figure, however, the limit seems almost to have been reached; the kelp seaweeds grow slowly, they appear to be subject to diseases, the gathering of the tangs is difficult and possibly destructive, and though the Bureau of Soils is still experimenting, also with respect to extracting the iodine and bromine from the weeds, the kelp outlook is hardly considered promising. We pass over the recovery of potash from beetroot pulp and wool scourings which does not offer new problems. Quite modern for the United States—though long practised to a small extent in Hungary, Russia and other countries—but equally local as the kelp industry is the lixiviation of the brines of certain salt lakes in the West of the States. According to Mr. Kirby Thomas there are hundreds of these lakes, mostly small and shallow, in Nebraska; the sand blown into them forms a false bottom over the impervious bottom so that the salts accumulate. The Sevier Lake Company is said to have sold 16,000 tons of salt, containing about 62 per cent. of commercial potash, in 1916. It is feared, however, that most of the occurrences will be exhausted within five years and the refinement of the potash salt by crystallisation is difficult. The native alum or alunite, an aluminium-potassium sulphate, of Utah and Colorado is another source which awaits development. The alunite works at Marysvale, Utah, where Mr. Chapelle is working, have twice had serious fires in the 2½ years of their existence. The mineral, only coarsely crushed, is mixed and heated with fine coal up to 900 deg. C. and digested with water in steel tanks; the solution is passed through Oliver filters and evaporated to gain a K_2SO_4 of 92 per cent.; the filter residue is an impure alumina which, it is interesting to mention, can be separated from its silica by flotation; at any rate the crude alumina is said to give a good refractory.

The recovery of potash from certain new materials now under examination, such as the feldspathic rocks, offers far more difficult, though not really novel, problems. The technologist only wishes to control and to hasten processes which Nature conducts at a very slow rate in uncontrollable ways, and many of the new processes are merely developments of well-known analytical methods. Feldspathic rocks are insoluble, complex silicates of alumina, the alkalis and other bases. In their natural decay the alkali is washed out and lost, and the residue of clay (kaolinite, aluminium silicate) and quartz sand in an impure condition has a very low value. In his laboratory the chemist can easily open up a few grammes of powdered feldspath and isolate the constituents by the aid of boiling water, lime, alkalis or acids. To work with tons of raw material is a very different matter, and the percentage of potash is generally far too small to justify the heavy expense of the operations, unless other products of some value can be obtained at the same time. It is little use to offer the residue as fertiliser; only good fertilisers cover the expense of transport. There is a commercial chance when the treatment yields either a cement or a clay that can

be worked for alumina. This new industry is hence largely combined with the cement industry.

Feldspars may broadly be classed as orthoclase or potassium feldspar $KAlSi_3O_8$, albite or sodium feldspar $NaAlSi_3O_8$, anorthite or calcium feldspar $CaAl_2(Si_3O_8)_2$, and as paglioclase, mixtures or compounds of albite and anorthite in varied proportions; oligoclase, labradorite and andesine belong to the paglioclase feldspars. In the orthoclase the potassium percentage may exceed 5 per cent. All these feldspars are minerals, however, which in the granite, gneiss, basalt and other rocks are combined with more quartz and with mica (magnesium silicates) and other minerals. The raw material for cement works will hardly contain more than 1 per cent. of potash. We will, however, first refer to the treatment of clays, the natural decay products of such rocks under special, hardly understood conditions, because those natural and artificial processes well illustrate the peculiar difficulties of the problems.

In India and other tropical regions very large areas are covered by the red earth known as laterite, an aluminium silicate, red with iron oxide, which does not appear to have been formed *in situ*. The glacial clays of America and Scotland seem to be the residue of the mud produced by the friction between the ice and the rocks over which it moved; they are also silicates of aluminium and iron, but rich in alkalis, probably because they were protected against the action of the atmosphere, rain and carbon dioxide, and therefore not leached out. The loess of China resembles the glacial mud, but is far more complex in its composition and contains many bases. Bauxite, an impure aluminium hydrate, is regarded as a secondary decomposition product of lava, formed by the precipitation of primarily dissolved alumina; the bauxite of the Antrim coast seems to be of this origin, but bauxite occurs under various, widely differing conditions. The alumina of the clay, even of bauxite, is now not directly utilisable. At the New York meeting we mentioned, Mr. A. H. Cowles spoke of many experiments he had made, in conjunction with Dr. A. Kayser, to furnace clay, mixed with salt and coal and exposed to the action of steam, in order to extract the alumina as sodium aluminate. Cowles emphasised that the mass must only be allowed to sinter in the furnace, not to fuse—to avoid volatilisation of alkali. In the ordinary treatment of bauxite this material is fused with soda to obtain sodium aluminate, which is lixiviated with water. In the process of K. J. Bayer—practically the only successful wet process, introduced at Tentelewa, near Petrograd, about 1895—the lixiviation is made with diluted soda. The bauxite is mixed with a little calcined soda, and heated to incandescence for 4 hours; the cooled mass is treated with weak soda lye, but only for 5 minutes to 10 minutes, lest the soluble sodium aluminate turn into insoluble aluminium hydroxide while still in the mass. Into the boiling solution carbon dioxide is then introduced to precipitate the alumina, whilst iron and other impurities remain in solution; the filtered alumina is finally dissolved in sulphuric acid and concentrated in copper boilers to a white salt fit for transport in casks. The soda is recovered in this process; but the prescribed conditions of the operations have to be closely observed, and the potash can hardly be separated from the recovered soda. Cowles recommended his process also for the recovery of potash.

We must return, however, to the consideration of feldspars. They can be decomposed by water and various chemicals, acids, bases, salts, and by wet or dry heat. The most effective reagents appear to be lime and calcium chloride. Lime has the advantage that a residue of the composition of a cement is left. But very large bulks of lime are needed, and in the wet process which is carried out with milk of lime at high pressure (250 lb. per square inch), the potash passes into the aqueous solution, from which it is difficult to recover, since there is practically no precipitant for potassium salts. Hence, so far, the wet lime process has only been applied to glauconite or greensand, a marine deposit of ferruginous potassium silicates, generally free from sodium. According to H. W. Charlton, of the Kaolin Products Corporation, New York, very little water is used, the potash solution can therefore be concentrated, and the residue yields sand bricks, as in similar processes. Mr. E. G. Spilsbury, however, apparently referring to another plant, mentioned that he ground the glaucenite together with the lime sand covering it in New Jersey, and furnaced it, mixed with a little sulphur, at 725 deg. C.; as described, that would be a dry potash process, without by-products. In the older, not yet industrial processes of Cushman and Cogshall, the feldspar is either mixed with common salt, which is to replace the potash in the feldspar, or mixed with chloride of calcium and lime. In the latter case the mixed ground feldspar and lime travel on a belt on which calcium chloride solution trickles down; each drop falling into the mixture balls up into a nodule of pea size; these nodules are screened off and pass slowly through a rotary kiln; the cold mass is leached with water.

In the dry furnace processes the feldspar is kilned with limestone instead of free lime, at high temperatures, 1,200 deg. C. and more. The potash of the feldspar partly reacts with the silica of the bricks, which is undesirable; some potash is lost by entering into other compounds; and part is volatilised, and only this part is recovered from the dust and fumes. It seems an odd way of extracting the potash, and yet at present it is regarded as more promising than others. It is on account of the volatility of potash salts that other methods avoid high temperatures. The Bureau of Soils has collected information from 104 American and nine Canadian cement mills as to their potash percentages. The raw mix contains from 0.2 per cent. to 1.16 per cent. of potash; by analysing the cement it is ascertained that about 2 lb. (in the best cases 2.4 lb.) of potash per barrel of cement obtained are lost during kilning, escaping with the dust and fumes. Assuming that the total production of Portland cement in the United States is 90,000,000 barrels per year, 87,000 lb. of potash would escape and might be recovered. The recovery is effected by electrical precipitation on the Cottrell system, *i.e.*, by exposing a slow current of the flue gases to a high-tension discharge. More than a dozen big cement works are treating their flue dust by this system. Unfortunately the potash fumes and dust particles are very fine and most apt to escape with the gas currents which must be maintained. As good insulation is essential for high-tension discharges, the atmosphere in the "dust treaters" is generally kept dry. To prevent the escape of the finest particles, however, sprayers are used in connection with Cottrell apparatus, while wet dust collectors are resorted to in several new works.

Attempts are also made to increase the amount of potash volatilised. The most obvious way is by blending the raw material; when the feldspar is rich in potash, but is too low in iron for the Portland cement to be made, iron ore is added. On the other hand the Security and Lime Company mix 1 per cent. of salt with the raw material, and have thereby nearly doubled the weight of volatilised potash without increasing the potash in the clinker, the soda replacing the potash in the clinker. The Riverside Portland Cement Company has successfully added fluorspar for the same purpose, with one curious undesirable result, however: the efficiency of the Cottrell precipitator went down badly, until water sprayers were introduced. So modified the fluorspar process is said to answer in the Ogden Cement Company, Utah.

Not all the potash dust recovered is soluble or easily soluble in water. There, however, the wet lime process, digestion of the dust with lime in autoclaves under a pressure of 50 lb. or 100 lb. per square inch at about 700 deg. C., certainly has proved successful for rendering the potash soluble, though curiously in the Alpha Portland Company the autoclave treatment decreased the solubility, until the digestion was carried out under admission of air. Information on these features and on the efficiency of electrical precipitation will be found in the account of six months' experiments given by B. F. Erdahl, of the Universal Portland Cement Company of Duluth, in the Journal of Industrial and Engineering Chemistry of May, 1918.

We finally come to the recovery of potash from blast-furnace dust, a source to which Mr. Wysor, of the Bethlehem Steel Company, drew attention, in 1916; his remarkably thorough research has done a great deal to stimulate these important investigations.* Mr. Wysor's ores and coke, however, were, it would appear, richer in potash than average raw materials are. In Scotland, where coal (not coke) is the usual fuel, Messrs. R. A. Berry and D. N. McArthur found the aspect less favourable; they communicated interesting figures on the amounts of dust collected in various blast-furnace plants and the potash in them in a paper which they presented to the Glasgow section of the Society of Chemical Industry in October, 1917; we commented on this communication in our issue of February 22 last. Statistics which the Bureau of Mines and Bureau of Soils are now compiling indicate that only 5 per cent. of the potash vapours escaping from the blast furnaces are actually found in the dust of the stoves and boilers. In the blast furnace, moreover, the charges can hardly be blended in such a way as to increase the potash percentage, as is possible in cement mills. Yet even this source deserves attention though chiefly perhaps because waste and nuisance go together in this as in many other instances. With potash prices at ten times the pre-war height much is feasible that peace conditions will rule out. But improvements in working conditions at any rate ought to survive the war, and they will do so.

THE BRITISH ASSOCIATION.

(*Concluded from page* 44.)

Colloid Chemistry in its Industrial Applications.

This committee (chairman, Professor F. G. Donnan, of University College, London; secretary, Professor W. C. McC. Lewis, of the Muspratt Laboratory, Liverpool), which was formed with the object of compiling information regarding the advances made in capillary and colloidal chemistry with special reference to industrial processes, had to take a broad view of the term "colloids." To illustrate its scope we may perhaps quote a few words—not verbatim—from the lectures on "The World of Neglected Dimensions" which Professor Wolfgang Ostwald, of Leipzig, delivered by invitation of the American Universities over there just before the war: "The clothes you wear are animal or plant gels dyed with other gels, colloidal in type, by processes of colloidal chemistry; the leather of your shoes is an animal gel closely relationed to gelatin, tanned with colloids; the wood of your chair is colloidal cellulose, the parts of the chair are held together by glue, a colloid in solid solution; the paper on which you write is colloidal, the body has been given with water glass, &c., the ink, rubber, &c., are all colloidal; the most common materials we work with are colloidal, and the details of technical procedure need be rewritten in the terms of colloidal chemistry." One need not go so far as to connect the setting of cements, the strength of metals, and the very nature of oils—not only of emulsions—with colloidal phenomena, as some enthusiasts do; but there certainly is a wealth of work to be done in this field. The classification of the subject, the report points out, may be as to properties and phenomena such as viscosity, coagulation, adsorption, &c., or as to technical processes, dyeing, tanning, &c. The committee has adopted both these methods, though it involves some overlapping, and this seems justified in view of the different theoretical standpoints from which the colloid problems are regarded. Whilst the school of Willard Gibbs treats the adsorption phenomena, especially of liquids, as capillary, other investigators explain the formation of films, especially of gases, on solid surfaces by the concept of unsaturated valencies. This first report of 85 pages deals only with one scientific factor, viscosity; as to the rest the classification is technical, there being reports on tanning, dyeing, rubber, &c.

* We noticed this research on page 108 of our issue of February 2, 1917, and would refer our readers to notes and paragraphs in our issues of December 15, 1916, page 593; March 9, 1917, page 236; and February 22, 1918, pages 204 and 209, as to potash recovery from rocks and furnace dust.

Each section is the independent compilation of one author, and bibliographies form a predominant feature of most of them. The object of the report is to collect material; the time for summaries has not come yet. We will briefly comment on the different sections.

In the section on the "Viscosity of Colloids," Mr. Emil Hatschek, of the Sir John Cass Technical Institute, London, reviews the literature on the subject since its general discussion by the Faraday Society in 1913,* when an excellent survey of the problem was presented. Smoluchowski later demonstrated that the electric charges on suspended particles contributed to the viscosity; the Einstein formula was modified by Hatschek, who proved that the viscosity was a function of the rate of shear and not, as is tacitly assumed in measurements with the capillary viscosimeter, independent of shear; and viscosimeters are being improved. Though viscosity measurements are important, however, as affording the most delicate means of tracing slight changes in colloidal solutions, the nature of the change, Mr. Hatschek concludes, remains a matter for speculation or for empirical interpretation.

The section on "The Colloid Chemistry of Tanning," by Professor H. R. Procter, of Leeds, points out that the skin is constituted of collagen (probably a polymerised anhydride of gelatin) and is physically a network of fibres of colloidal jelly, themselves bundles of finer fibres, under an outer coat of epidermis; in the dry raw hide the fibres harden to a horny mass, and the tanner has to treat the hide, by surface coating, fermentation or chemical changes, so as to leave the fibre flexible whilst no longer subject to putrefaction. This can be done in various ways which are not all covered by the same explanation. Roughly one may perhaps say that the hide, being softened and swollen in acid or alkali, has again to be dihydrated without making the fibres re-adhere to one another, and to be coated with impervious materials; this can be effected with the aid of alcohol, salts (of aluminium, chromium, iron), tannins, and fats; but it is hardly advisable to generalise in this way, as Professor Procter's able review shows.

"The General Review and Bibliography of Dyeing," by Mr. P. E. King, also of the University of Leeds, discusses the very varied and voluminous literature on the four theories, the mechanical or physical, the chemical, the colloid diffusion and adsorption theory, and the electric theory of dyeing. The latter two of these theories are more recent and supplementary to the two former, the first of which regards dyeing as an adsorption of the dye by the fibre, whilst the second believes in actual chemical combination between the two, or salt formation. That the dye is not merely adsorbed by the fibre seems clear after Justin Mueller's observation that pure charcoal (free from organic nitrogen compounds) is a very poor adsorbent of dyes; on the other hand Georgievics showed that glass beads and kaolin take a dye like cotton or wool, whilst there are undoubtedly many cases of chemical combination. These controversies are by no means new, of course. Mr. King quotes a number of authorities sufficient almost to bewilder the reader, but he expects a development on the lines of the likewise fairly old theory of adsorption plus electrolytic dissociation and electric charges, as more recently put forward by Pellet-Jolivet, who suggests a dissociation of the dye and of the water.

In his review of the "Colloid Chemistry in the Fermentation Industries," Professor Adrian J. Brown, of Birmingham, contents himself with a bibliography, giving in some cases brief abstracts of the papers. The same plan is adopted by Dr. H. P. Stevens in the section on "Rubber."

The long section on the "Colloid Chemistry of Starch, Gums, Hemicelluloses, Albumin, Casein, Gluten and Gelatin," by Mr. H. B. Stocks, of Birkenhead, is more of the review type again. As to "Colloids in the Setting and Hardening of Cements," by Dr. C. H. Desch, we would refer our readers to the recent discussion of the Setting of Cements by the Faraday Society.† The three remaining sections, "Nitro-Cellulose Explosives from the Standpoint of Colloidal Chemistry," and "Celluloid" by Mr. E. R. Chrystal, and "Colloidal and Capillary Phenomena in their Bearings on Physiology and Bio-Chemistry," by Professor W. Ramsden, of the Bio-Chemical Laboratory, Liverpool University, are short; Professor Ramsden also confines himself to a bibliography.

* ENGINEERING, April 26, 1913, page 431.
† ENGINEERING," January 18, page 71, and February 1, page 109; 1918.

ENGINEERING PROBLEMS AND THE FUTURE PROSPERITY OF THE COUNTRY.

The report of a Committee of Section G., Engineering, on "Engineering Problems affecting the Future Prosperity of the Country" (chairman, Dr. H. S. Hele-Shaw; secretary, Professor G. W. Howe) is brief and commendable for its common sense. The committee was formed as a result of suggestions made by the chairman in his sectional address at Manchester, 1915, when the war was comparatively young. Sub-committees were formed on (1) scientific research in relation to engineering; (2) patent laws; (3) revision of catalogues especially in relation to the metric and decimal systems; (4) labour problems, and reports, especially on (1) and (4), were prepared and circularised. As the same questions were meanwhile taken up by other bodies and committees, the committee does not at present ask for re-appointment, though it considers that there will be important work for an independent body to review the operation of the various agencies and their recommendations at a future date. Further, as the Association has to limit printing as far as possible, the committee decided to deposit the draft reports and documents prepared in the offices of the British Association, where they may be inspected or copied.

SCIENCE IN SECONDARY SCHOOLS.

The lengthy report of the Committee on "Science in Secondary Schools" (chairman, Professor R. A. Gregory; secretary, Dr. E. H. Tripp) is a very instructive compilation which will repay study, especially also in connection with the recent discussion on the "Teaching of Physics" to which the Physical Society devoted 3 hours on June 14 last.* To the British Association the subject is one on which it has exerted formative influence since 1866. At that time it was strongly urged that the teacher should make the pupils of his class teach themselves, thinking the lecture out with them, taking up their suggestions, criticising and hunting them down, and starting them on a fresh scent, as Canon Wilson, of Rugby School, expressed it. The method—novel then for school practice—became later known as the analytical, heuristic or common-object method; it proceeds from the concrete to the principle and places the students in the attitude of the discoverer, letting him find out things rather than telling him about them, by starting from a steam engine or an electric bell and working down to thermodynamic and electric principles, *e.g.* The other method, the synthetic, begins with the elementary principles and builds up. Both methods have their advantages and pitfalls; Wilson had already advocated a union of the two, and the differences are, perhaps, not so great in practice as in theory. But most people will probably agree with Sir Oliver Lodge, from whose opening of the Physical Society's discussion we have partly quoted, that the systematic course beginning with principles is preferable for science teaching at school. Professor H. E. Armstrong, who has been a member of several of these British Association Committees, and who introduced the heuristic method for the teaching of chemistry in schools and contributes "Suggestions for a Course of Practical Food Studies" to this report, himself doubts whether strictly heuristic methods are practicable with large classes.

The report reviews the position of science teaching in secondary schools of different types. There are first the State-aided schools, including the old-established grammar schools, as well as municipal and county schools under the Board of Education or local education authorities. The boys' school of these classes number 620; they are all represented on the Incorporated Association of Headmasters, the Conference of which further comprises representatives from 120 schools, admitted on the condition that the school has at least 100 boys, and that about 10 per cent. of its pupils are resident undergraduates at Oxford or Cambridge, direct from the school—a qualification the wisdom of which may not be apparent to the general public. The cognate Association of Headmistresses represents 415 public secondary schools for girls, of which 330 are State-aided. The report shows which branches of science are taught to pupils at different ages, from 11 to 16 or 18 years, and discusses the values of individual practical work, laboratory demonstrations and lectures, rightly emphasising the human aspects of science. There follow sections on the supply of teachers and their salaries, on academic qualifications of headmasters, and on inspection and examinations, for testing both schools and individuals. Special attention is directed to the knotty question, whether examination papers should be set by the teachers or by official examiners and visiting authorities. The report further contains detailed schemes for typical science courses, drawn up by Mr. Archer Vassall, of Harrow; Mr. F. W. Sanderson, Headmaster of Oundle School; Professor Percy Nunn, of London University; Mr. W. Aldridge, Headmaster of Shepton Mallet Grammar School; and, further, by Misses I. M. Drummond and R. Stern, and by Miss Lilian Clarke for girls' schools.

The remark, made by Professor Lees in concluding the discussion by the Physical Society, will meet with general approval. Science should be taught at secondary schools for its own sake, and not in preparation for the university studies. We may perhaps add a few remarks on some points which were hardly touched upon in this report and in the discussion by the Physical Society. The great actual and increasing difficulty is to find the efficient teacher. The teaching profession is not inferior to others. But the usual qualifications, academic studies and degrees, are no guarantee for a capacity of imparting knowledge, and with the analytical method in particular everything depends upon the individual fitness of the man in charge of a class, whilst even a moderately-gifted teacher may attain fair results, if he follow a good schedule, and his pupils be provided with suitable text books. Further, the teacher should adapt his instruction to the average standard of his class, and not concentrate his attention upon a few promising pupils who, by securing high marks and scholarships, will enhance the reputation of the school. Examinations, scholarships and marks are too much tied up with red tape and encourage cramming. The examiner will easily be able to decide whether or not a pupil should pass; to make him assess marks so as to settle, whether A is by a whole or a fraction of a per cent. superior to B, is both absurd and unfair. If in revising the status of State-aided schools, scholarships were abolished or levelled and reserved for the benefit of the indigent, much of the examination nuisance and many of the difficulties of the teacher would vanish to the benefit of fairness and general efficiency. We do not speak of grants for research made to students who have proved their capability; that is an altogether different matter. The State has to give every child its educational chance; the rest must be left to the individual.

* See ENGINEERING, July 12, page 31.

NOTES.

THE THOMSON-JOULE EFFECT.

IN 1853 William Thomson and Joule described in the Royal Society experiments on the cooling which a gas undergoes when expanding adiabatically without doing external work. In this and in subsequent measurements of the Thomson-Joule effect the pressure and temperature ranges were small, and the air expanded through a reducing valve, the low-pressure side of which communicated with the atmosphere. The dependence of the effect on pressure and temperature was not determined, therefore. Experiments at pressures up to 150 atmospheres and temperatures ranging from — 55 deg. up to + 250 deg. C. were begun at the Technical High School of Munich some years ago by E. Vogel and continued by F. Noell, who describes them in the *Zeitschrift des Vereines Deutscher Ingenieure* of February 2 and 9, 1918. The apparatus, partly supplied by C. von Linde, comprises two Whitehead

compressors and is so arranged that the air circulates in a closed cycle; the reduction valve consisting of a plug of compressed asbestos is placed in a thermostat, and the air is, in the different experiments, heated electrically or cooled by flowing through coils of steel which are arranged on the counterflow principle and placed in baths of liquefied ammonia, carbon dioxide, &c. The heated or cooled air is compressed and passed through the valve so that a steady pressure fall or difference, mostly of 6 atmospheres (sometimes of 8 or 10) is maintained; when steady conditions are attained, which may take an hour or longer, the experiments proper begin, readings being taken at intervals of 5 minutes. The absolute pressures are measured by hydraulic gauges, the pressure differences Δp by differential mercury gauges, the temperatures t by Beckmann thermometers (within 0·01 deg. C.), and the temperature differences Δt by platinum resistance thermometers; the platinum coils were placed in glass tubes as contact with the hot air affected their resistance permanently. Determinations were conducted at — 55·4 deg., — 34 deg., — 0·6 deg., + 49·2 deg., 99·3 deg., 149·7 deg., 199·3 deg., 249·9 deg. C. at pressures up to 150 atmospheres, about a dozen experiments being made in each case. The actual Δp was generally 6 atmospheres, as mentioned, the Δt was about 2 deg., when experimenting at the low temperatures, diminishing finally to 0·1 deg. at the highest temperatures used. The cooling effect Δ, *i.e.*, the quotient $\Delta t / \Delta p$, expressed for a pressure change of 1 atmosphere, decreased from nearly 0·5 deg. C. at low pressures and temperatures to about 0·1 at high pressures and temperatures, the diminution of the cooling effect being linear at all temperatures. This diminution was expected, but had not so far been measured. Thus, when the $\Delta t / \Delta p = \Delta$ are plotted as ordinates against the pressures as abscissæ all the curves are straight lines converging apparently to a point far out on the high pressure side of the abscissa, but with a small ordinate of less than 0·1 deg. C.—that is, it looks so, as far as the experiments go. What would take place at extremely high pressures is not known yet, of course. When the $\Delta t / \Delta p$ are plotted against rising temperature, converging curves are also obtained, but they deviate from straight lines, in the high pressure-low temperature region especially. If extrapolation of the empirical formula of Noell be permitted, however, the so-called inversion curve can be determined. There should be for every temperature a certain pressure for which the cooling effect Δ becomes zero; if the pressure be further raised, the cooling should change into heating, and there should be an inversion; hence as the respective points depend upon both temperature and pressure, it is more correct, however, to speak of an inversion curve than of an inversion point. Noell's inversion curve now approaches the curve which the equation of state of Van der Waals would give, better certainly than the Dieterici equation; but there is no real coincidence, nor was that to be expected. It is further interesting that the specific heat Cp of air, deduced back from Noell's experiments, agrees well with the specific heat as determined by Holborn and Jakob, especially for 60 deg. C.

Action of Iron Oxide on Silica Bricks.

Assuming that the pouring temperature of steel is about 1,650 deg. C., and that the best silica bricks have a melting point of 1,750 deg. C.—which is probably too high a figure—it will be understood that slight excesses of temperature in the steel furnace may do serious damage to the arches which are built up of silica bricks for want of any better material. Apart from the direct action of the heat, the local effects of the flames, the gases and particularly the dust and liquid metal from the charge and the bath, are the chief factors which endanger and modify the bricks. In a recent communication to the Paris Académie des Sciences Rengade distinguishes four zones in the bricks which have done service for some time. Proceeding from the hearth upward he designates these zones by the letters A, B, C, D, D being the unaltered portion of the bricks highest above the bath. The same number of the *Comptes Rendus*, of May 13, 1918 (pages 764 to 769) also contains a paper by H. Le Chatelier and B. Bogitch, dealing particularly with the effect of the iron and its oxides on the bricks. Le Chatelier states that his conclusions agree absolutely with those of Rengade; to us there appear to be differences sufficiently striking to question at any rate the "absolutely." The zones of Le Chatelier are: A, a gray zone in which the original silica of the brick has more or less undergone fusion and been turned into tridymite and cristobalite; a black-brown zone B, of large crystals of tridymite in a blackish-ferruginous medium; a zone C, in which whitish spots, fragments of the original brick particles, can be distinguished which have not quite recrystallised into tridymite or still show a nucleus of cristobalite. Tridymite and cristobalite, we may add, are modifications of amorphous quartz, to which different authorities assign different temperatures of transformation. Rengade, Le Chatelier proceeds, also speaks of regions of light yellow in the dark brown zone C, which Le Chatelier would distinguish as a separate fourth zone; but Rengade does not make mention of any yellow patches, nor does he refer to sulphates of which Le Chatelier finds, *e.g.*, 10·5 per cent. in the original brick, and 29·5 per cent. in zone C. They both state that much more iron oxide (4 per cent. or 6 per cent. according to Le Chatelier, up to 19·5 per cent. according to Rengade) is found in zones B and A than the 1 per cent. of the original brick. We will follow Le Chatelier in our further remarks. The grey zones directly exposed to the flames and to the ferruginous dust are less rich in basic oxides than the zones higher up, and in the brown or yellow portions lime accumulates, especially with relatively rapid fusion. The iron oxide ascends in the capillaries of the bricks; when a new brick free of iron is placed upon another rich in iron, the iron will after heating for an hour to 1,600 deg. C. have travelled upward into the new brick to a height of 5 mm., especially in a reducing atmosphere. When a pill of compressed iron oxide is placed on the top of a silica brick, which is heated to 1,200 deg. C., a hole is formed of the dimension of the pill, and ferrous silicate diffuses into the brick; in an oxidising atmosphere the pill remains intact even at 1,400 deg. C. That the basic oxides diffuse, is due to the fact that the brick, where directly exposed to the flames, contracts, loses its porosity and squeezes the ferrous slag out, forcing it into the colder portions. This shrinkage may lead to the formation either of semi-fused patches, which fall off, or completely-fused stalactites. Metallic iron, sprayed on to the bricks in drops or placed on them, gives rise to the formation of holes, protoxide and an easily-fusible slag being formed. As regards the enrichment of lime in certain zones Rengade says that the lime silicate fuses and rises in the capillaries, whilst Le Chatelier maintains that it is the ferrous silicate which sweeps the silico-aluminate of lime out, so that most lime is found there where the iron stopped in its rise. This he demonstrated by placing a new brick on a cushion of iron oxide at 1,600 deg. C. As a brick containing 5 per cent. of lime may have its melting-point lowered by 100 deg. C., this migration of the lime in the bricks is of great importance for the durability of the arch, and for this reason chiefly local excessive heating of ferruginous silica bricks is so injurious.

Payments to and on Behalf of "Enemies" in Respect of Patents, Designs and Trade Marks.—The Board of Trade give notice that they have revoked the general licences of December 7, 1915, and September 8, 1917, under which, subject to certain conditions, the payment was permitted of fees, &c., due in enemy countries in respect of the grant, registration or renewal of patents, designs and trade marks, and also the payment in His Majesty's Dominions and Allied Territory on behalf of enemies of similar fees, &c., in respect of such industrial property. All such payments are consequently prohibited in future.

Progress of Education.—Education is adapting itself rapidly to the altered conditions which have arisen through the war. At the East London College (University of London) special courses are provided for those wishing to enter the Air Service or to study aeronautics. In conjunction with the London Hospital a preliminary medical course has been arranged which should help to meet the demand for medical men, while for women desirous of receiving a university training in arts or science or for chemical industries additional facilities are offered by the institution of a residential hostel.

LITERATURE.

Mathematics for Engineers. Part I. Including Elementary and Higher Algebra, Mensuration and Graphs, and Plane Trigonometry. By W. N. Rose, B.Sc.Eng., London: Chapman and Hall, Limited. 1918. [Price 8s. 6d. net.]

A Text-book for Students in Technical and Trade Schools, Evening Classes, and for Engineers, Artizans, Draughtsmen, Architects, Builders, Surveyors, &c. By Edward L. Bates and Frederic Charlesworth. Second Edition. Revised. London: B. T. Batsford, Limited. 1917. [Price 5s. net.]

In the preface to the former of these works, the author states that he has attempted to produce a treatise "so thorough and complete that it shall embrace all the mathematical work needed by engineers in their practice and by students in all branches of engineering science." Such an encyclopædic scheme strikes us as a little too ambitious, and as liable to fail by taking too small an estimate of an engineer's requirements. In recent years proposals have been made to improve the scheme of mathematical training, but curtailment or reduction of analytical power was not contemplated. Subjects once considered recondite and only to be approached after a long preparatory course have been attacked, and successfully attacked, at an earlier stage, infusing greater interest into the curriculum, but the necessity for wider scope and additional requirements has been extended rather than diminished. The civil engineer of the past generation may have been adequately equipped for his work, though his mathematical attainments were slender. As mechanical engineering acquired increased importance, the assistance that mathematical training could render naturally widened. Modern high-speed machinery has given rise to many interesting problems, and given opportunity for further mathematical application. A new type of engineer has been created by the development of electric energy. As improved shipbuilding brought out new problems in construction in the last century, so the aeroplane has been equally productive in this. It is impossible to doubt that inevitable progress will demand from the student of the next generation more and better equipment than suffices now. We are sure the author would not wish to minimise the amount that will be required from the engineer of the future. The so-called "practical mathematics"—an unfortunate term—is responsible in a great measure for the mistaken, or disproportionate, view that sometimes prevails, and a plea for a wider outlook than is indicated by the contents of some recently published works becomes occasionally unavoidable.

Mr. Rose contemplates a further weighty contribution to the present treatise, so that it would be premature to decide on the amount of equipment that he thinks necessary or desirable. But the emphasis put upon arithmetical processes, or on the solution of simple equations and much other elementary matter, seems out of place. Such ordinary operations appeal with no more special urgency to engineers, than to clergymen or stockbrokers. The space devoted to these explanations seems unwarranted here, such preparatory work belongs to elementary education generally. With the chapter on mensuration the technical work may be said to begin and the treatment here appears very thorough and satisfactory, the selection of examples supplying a very necessary link with engineering work generally. The introduction of a table of land measures based on the chain and link is to be commended. It marks a great improvement on the old abomination of rods and poles, that wearied the teachers and troubled the children of many generations in the past, and it is to be feared will in the future. The insistence on the use of the slide rule and of the planimeter is to be encouraged.

The construction of graphs naturally claims much attention and the applications of the principle are both instructive and practical. It is unfortunate that the discussion is so scattered owing to the interpolation of chapters on various elementary subjects. In the introductory portion, some applications are made that include the solution of quadratic equations and some maximum and minimum problems afford suggestive examples. Graphs representing trigonometrical and exponential

functions are reserved for a future chapter, in which is also exhibited the construction of P V and $t\rho$ diagrams. The solution of a class of problems by the application of similar processes recurs again, in the consideration of details connected with chart construction. Some of these are eminently practical, time-saving, devices, but seem rather far removed from mathematics in the ordinary acceptation of the term.

To return to the more purely mathematical portions, we have a chapter on Algebra in which arithmetical and geometrical progression are touched upon, and again, as we think a little unfortunately, this section is separated from similar elementary work on permutations, the binomial theorem, &c., by half the book. Plane trigonometry is treated consecutively in one chapter, and gains by this unity of handling. The author favours the method of reckoning angles continuously from 0 deg. to 360 deg., ignoring the sub-division into quadrants. In this arrangement we are quite sure he is right, it is the only way to avoid a frequent source of error, arising from having too many axes of reference. It is a matter more pressing on the navigator possibly than the engineer, but the former is so wedded to his notation, and so conservative in his habits, that innovation is out of the question. With the engineer and the land surveyor, more success may be anticipated. The introduction of a few pages on hyperbolic functions is of doubtful advantage. At best such a sketch might furnish a reader with a process, that would enable him to follow the reasoning in a problem where such an artifice was applied; it would not give him that analytical power which would give him confidence in making an independent application of the functions.

After this excursion into the domain of pure mathematics the author returns to practical matters, giving an excellent chapter on the planimeter, an instrument that has perhaps been too much neglected, but which modern improvements and more accurate workmanship have made reliable within recognised limits. Still severely practical, and therefore eminently useful, the author discusses a series of examples, illustrating the method of calculating types of earthworks problems, such as occur in connection with railway cuttings, embankments, and excavation work.

The author has brought together very much useful information, his explanations are usually clear and exact, and his diagrams well drawn. The examples appear to be judiciously chosen, are of an eminently practical character, and sufficiently numerous. The arrangement of the chapters, or the order of presentation of the material, as we have hinted, leaves something to be desired, but this is a matter of opinion, and doubtless some other plan would be found to be accompanied by some corresponding disadvantage. Not a small portion of the value of the book lies in the examples; these are varied in character; many of them must be distinctly original and in those instances where the interest has led to an examination, we have found them accurately solved.

2. The second book, which naturally covers much the same ground as the preceding, is the second edition of a work that originally appeared six years ago, and apparently has enjoyed a *succès d'estime*. It is satisfactory to know that the book has met with great favour in many technical schools, both at home and abroad. This is as it should be, for the authors carefully catered for the needs of working students. Amended by the friendly criticism of many teachers and of struggling self-taught pupils, a further life of usefulness lies before the present edition. The author, to whom we offer our respectful sympathy, has been deprived of the helpful collaboration of his colleague, Mr. Charlesworth, who died while the present edition was in course of preparation.

The authors have planned a complete course intended to cover two or three years' instruction, and no previous knowledge on the part of the student is assumed. No doubt they have struggled, and we hope successfully, to remove all the difficulties out of the way of the reader. It is, however, impossible to place oneself in the position of one who approaches a novel problem, without other assistance than the written description. That they are aware of the difficulties and the pitfalls that await the tyro is shown, perhaps, by the fact that about two-thirds of the book are devoted to arithmetic, elementary algebra and geometry, savouring the whole with some references to differentiation and integration, a sketch that may serve as an introduction to, and point the necessity for, more advanced text books. In the solution of algebraical problems, graphical construction is frequently applied, but it might not be out of place to suggest that a dangerous facility for plotting curves from their equations may reproduce some of the evils, which the introduction of graphs was intended to abolish. It is desirable that a student should plot envelopes as well as loci, but this task does not seem to receive much attention.

Under geometry may be included mensuration, and the method of treatment appears excellent. The examples are generally suggestive and stimulating, and to find practical intelligent questions is not an easy task. Trigonometry has apparently suffered from not being introduced sufficiently early. When the authors were dealing with triangles and circles it would have been convenient to have explained trigonometrical functions, and the method of solution of triangles. Then perhaps we should have been spared the anomaly of banishing so elementary a proposition as the expression of the sine of the sum of two angles to an appendix. Later, a chapter is given on Elementary Vector geometry, which, like those referring to the differential and integral calculus, carries us but a little way forward.

Tidal Lands: A Study of Shore Problems. By ALFRED E. CAREY, M.Inst.C.E., and F. W. OLIVER, F.R.S., Quain Professor of Botany in University College, London. London: Blackie and Son, Limited, 1918. [Price 12*s.* 6*d.* net.]

THE modification of coastal outline is continuous owing to the action of many and apparently capricious agencies. The forces of destruction are increasing, calling for alert watchfulness and the provision of special devices, which it is the province of the maritime engineer to supply. Erosion is the main agent of destruction; the tireless ocean moved by the energy of tidal action and of wind forces breaks down the natural defence of cliff and sea wall, carrying off piecemeal the compacted materials to raise the sea bottom, with increased opportunity for covering low-lying beaches. Whether wave action or current flow is the operative cause in promoting denudation and accretion is uncertain, and local conditions are equally an unknown factor in the general problems, but the fact remains that the shore frontage retrogresses in some places and advances in others by reason of the sand, shingle and mud that are deposited. Evidently there are two main divisions to be considered in these shore problems, the prevention of denudation and the utilisation of the scattered materials that are drifted to other localities. The protective measures consist in building up sea walls of masonry or timber, that will prevent the access of tide or wave to the erosable surface, in providing systems of groynes along the foreshore to prevent the travel of movable beaches, and in similar precautionary devices. These are often not so successful as could be wished because of the uncertain hazards and obstacles by which the path of the maritime engineer is plentifully bestrewn, but we are conscious that steps are being taken to counteract the work of destruction and are hopeful of the result. The conservative forces working silently and imperceptibly are equally unceasing, but as their action is spontaneous and inexpensive they attract less attention. The most kindly of these beneficial agencies is vegetation, whose work we are practically powerless to stop and, as a rule, too indifferent to assist.

The ocean, carrying the spoil derived from cliff and rampart in racing over tide-washed lands, is compelled to yield some of its illgotten gains of sand, shingle and mud on the flats and marshes that are temporarily covered. The surface is gradually raised, fewer and fewer tides pass over it, the topmost layers become firm and stable and then vegetation has its chance, a slender one it may be, but in the long run effective. The wind and the water bring seed, and though the conditions for establishment are insecure, they constantly tend to improve. Many of the early seedlings fail to mature, nevertheless, the decaying material retards the rate of flow of water automatically, causing the current to drop more and more of its burden, thus forming a more promising habitat for the next season. More roots and rhizomes are the consequence, more obstruction to the ebb and flow of the water, all tending to reduce the mobility of terrain, to the accumulation of silt, to the raising of level, and to making the action of wind and tide of less effect.

Since measures to limit the ocean's destructive force and to encourage the beneficent work of Nature are equally desirable, the co-operation of an engineer and a botanist in the study of shore problems is happy and desirable. The knowledge and experience of both can be turned to good account, as this work amply demonstrates. The result is a very interesting book, and being written in a popular style, should arrest the attention of an island people generally, for it raises, if it does not solve, many problems in which we are all intimately concerned, but which too often escape notice by reason of the uniform operation of familiar causes. The dashing of the waves on the marine promenade fails to remind us of the serious depletion those same waves are working elsewhere, night and day, the music of the rolling shingle does not impress us with the value of a belt of protecting medium whereby our seaboard is fendered, or convince us of the criminal folly involved in its neglect.

Mr. Carey tells us something of the tides, their causes, and the methods by which their fluctuations are predicted. Herein he appears to be guilty of one or two slips. We cannot admit his assertion that as a rule tides are low in April and May (page 134). In these months the moon's parallax is as likely to be at a maximum at times of Full and Change as in any other month, owing to the rapid revolution of the line of apsides. Again, in April, full and new moons would occur when the moon is near the equator, and such conjunctions are favourable to high tides. Scant justice is done to Mr. Edward Roberts in intimating that the National Physical Laboratory designed the India Office tide predicting machine. Mr. Roberts computed, or predicted, the Indian tides from this machine many years before the National Physical Laboratory was in existence. But the volume under notice has more to do with the mechanical effect of the tides than with their origin, and the few details that are given concerning the method of prediction may be regarded as unessential.

Mr. Carey is a safer guide in the work of actual construction, though unfortunately the adoption of plans and their complete execution cannot be guaranteed to produce a result with absolute certainty. The history of coastal defence contains many examples in which unforeseen agencies have baffled experience and defeated well-matured schemes. Nowhere is the study of failure and the contributing causes more necessary and instructive, and the authors quote many examples for our warning and guidance. Operations are, and must be, tentative, for the forces against which the engineer works are as obscure in their origin as they are complicated in their effects. It is not too much to say that in no branch of engineering practice does similar uncertainty exist, or so many antagonistic forces tend to counteract schemes founded apparently on trustworthy data. Each scheme has to be considered on its own peculiarities, difficulties and advantages. If a new problem bears some resemblance to one that has been successfully followed, it will generally be found that some unexpected combination requires a quite different solution. To attempt generalisations is to court a misleading myth, and classification is to be shunned as of doubtful utility.

The plan hitherto pursued in coastal preservation may be described as one of trial and error. The trials perhaps now involve less risk, and the errors are becoming fewer in number, but many schemes have proved not only expensive but have entailed evil consequences on posterity. The simplest and most familiar form of defence is the construction of a system of groynes. The plan has been longest practised, but experience has not brought uniformity, and every variation of design is to be encountered round our coasts. The test of good design in

groynage is equality of accumulation of littoral drift to windward and leeward of structure. It is a test that is easily applied but generally with disappointing results. The author instances the three towns of Dover, Brighton and Hastings as demonstrating a vicious circle of original bad planning, which has wrought much destruction of the coast line. The towns have gradually grown up to an arbitrary sea contour, and there is nothing for it but to maintain that artificial frontage. It must not be supposed, however, that the author indulges only in criticism. Two chapters on plans for Land Reclamation and on Erosion and Accretion are replete with practical hints, that will contribute to judicious and well-devised construction.

Professor Oliver's contribution has something of the charm of a fairy tale. His object is to show how the constructive works of the engineer may be usefully supplemented, and even replaced, by making use of vegetation to reduce the mobility of terrain, and by accreting matter build up a soil that shall give economic value to the shifting waste of sand. A brushwood fence planted in a sand-laden windway will raise a pile of sand to its own height, but no higher: on the other hand, a living plant, which continually grows higher and higher, projecting beyond the sand heap it collects, will stop the passage of a sand dune of considerable proportions. The choice of a plant best calculated to meet the inhospitable conditions that drifting sands offer is of prime importance, and Professor Oliver shows how Psamma, among others, will accommodate its growth to the increasing level of accumulated sand by continually pushing up new leaves from freshly-formed rhizomes, the decaying parts tending to form the humus that will pave the way for other forms of vegetation. The pioneer plants, whatever they be, are only suited to their special habitat and inevitably give way as the changing conditions render the ground suitable for the entrance of other species, which after replacing the pioneers, are themselves superseded by yet others. The law of progressive development through definite phases is rigorously maintained. In France, on the ground that Psamma grass has stabilised and reclaimed from shifting sands, seedlings of the maritime pine have been planted, and from the forests thus created, pit props in enormous quantity have been produced, 600,000 tons annually being sent to this country. In these days of compulsory substitutes, Psamma grass has been suggested and possibly used in the manufacture of paper, in the place of esparto, and the proposal that our sand dunes should be utilised to produce an article of economic value should not be neglected.

Shingle under wave impact forms an insecure foundation for vegetal growth, and it would seem a hopeless task to bind such incoherent material by vegetation sufficiently robust to defy the violence of the elements. Many species, however, find a satisfactory home among this littoral drift. But there is one plant, *Suæda fruticosa*, that is pre-eminently useful and is capable of itself of accomplishing the task of stabilising the shingle beach. On dormant shingle specimens grow to a height of 3 ft., with stems 2 in. in diameter. These can well take care of themselves, but on mobile shingle the young plant has a rough time, being often prostrated by the flowing drift. When overwhelmed, it does not die, new erect-growing branches rejuvenate by the elongation of lateral buds, so that for each branch laid low a sturdy thicket appears. By the second year, each buried branch becomes an independent plant capable of holding shingle, and this unlimited capacity of vegetative rejuvenation when capsized, gives the victory to the growing bush. The *Suæda* has other good qualities, but on these we must be silent. It is enough to say that the author considers a well-devised attempt at afforesting maritime shingle with the assistance of this grass would prove successful.

Salt marsh and mud flat are equally amenable to vegetative treatment, but botanical regulation is necessary to encourage proper reclaimers and to guide exuberant growth. A *Spartina* that within the last few decades has made its appearance in the muddy flats adjacent to Southampton Water illustrates both these points. Its spread has been remarkable and it has acted beneficially as a reclaiming agent in consolidating the soil. But its marked increase in navigable waters may constitute a serious menace to traffic, and the recovery of a few square miles of marsh land would ill compensate for impaired facilities of navigation. The possibility of conflict between the interests of navigation on the one hand and those of land owners and sea frontagers on the other, raises the question of control and management of tidal lands in an acute form. The authors discuss the relative advantages of State control *versus* local authorities with moderation, and ample knowledge. They have a good word to say on behalf of the Level Commissioners, and a policy of strengthening their hands under the Board of Trade is considered. To constitute the Board of Trade the sole sea defence authority of the realm, without local guidance in specific instances, is attended with some danger. The case of Hallsands, a village near Start Point, is quoted, as illustrating the necessity of acting on local knowledge. Hallsands was efficiently protected by sea walls and a wide beach till 1896, when Sir J. Jackson obtained permission from the Board of Trade to dredge sand and gravel for work in Devonport Dockyard. Some 650,000 tons were removed, with the result that the sea wall was undermined, the protecting coast line collapsed, and the village was ruined. The pithy comment is made, that under the specific authority of a Government Department, entrusted with the sole administrative control of foreshores permission "was granted to carry out operations, the effect of which was for practical purposes to destroy a coast line of immemorial stability."

BOOKS RECEIVED.

Tables of British Decimal Coinage, Metric and British Weights and Measures, Areas and Circumferences of Circles, the Force of Gravity at Different Places, Resistance of Trains on Level Straight Track, Resistances due to Gradients, Maximum Safe Speed of Trains on Curves, Super-elevation of Outer Rails, Curve Ranging Tables and Earthwork Measurements on the Metric System. By A. J. LAWSON, M.Inst.C.E. London: Eyre and Spottiswoode, Limited. [Price 5*s.* net.]

Industrial Fatigue and the Relation between Hours of Work and Output, with a Memorandum on Sickness. By LORD HENRY BENTINCK, M.P. London: P. S. King and Son, Limited. [Price 6*d.* net.]

Department of the Interior, U.S.A., Bureau of Mines. Technical Paper 155. *Mineral Technology.* 19. *Gypsum Products, their Preparation and Uses.* By R. W. STONE. Washington: Government Printing Office.

The Cold Storage and Ice Association Proceedings. Vol. XIV. London: Published by the Association 22, Basinghall-street, E.C. Price 2*s.* 6*d.* net.]

Sterling Decimal Coinage with Analysis of the 1918 Decimal Coinage Bill. By WALTER LENNOX CRAIG. B.C.E.(Melb.), Assoc.M.Inst.C.E. London: Effingham Wilson. [Price 2*s.* 6*d.* net.]

Mensuration Made Easy, or the Decimal System for the Million. By CHARLES HOARE. London: Effingham Wilson. [Price 1*s.* net.]

Bulletins of the United States Bureau of Mines. No. 130. *Blast-Furnace Breakouts, Explosions and Slips, and Methods of Prevention.* By F. H. WILCOX. [Price 30 cents.] No. 135. *Combustion of Coal and Design of Furnaces.* By HENRY KREISINGER, C.E. AUGUSTINE and F. K. OVITZ. [Price 20 cents.] No. 140. *Occasional Hazards at Blast-Furnace Plant and Accident Prevention.* By FREDERICK H. WILLCOX. [Price 30 cents.] No. 141. *Year Book of the Bureau of Mines, 1916.* By VAN H. MANNING. [Price 30 cents.] No. 148. *Methods for Increasing the Recovery from Oil Sands.* By J. O. LEWIS. [Price 15 cents.] No. 153. *The Mining Industry in the Territory of Alaska during the Calendar Year 1916.* By SUMNER S. SMITH. [Price 15 cents.] Washington: Government Printing Office.

Shipbuilding Cost Accounts and their Relation to Management, Estimating and Accountancy. By GEORGE F. MCGREGOR. South Shields: The *Gazette* Office, Barrington-street. [Price 3*s.* 6*d.*, or 3*s.* 9*d.* post free.]

Coal Mines Excess Payments: Guarantee Payments and Levies for Closed Mines. By W. E. SNELLING. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

General Lectures on Electrical Engineering. By CHARLES PROTEUS STEINMETZ, A.M., Ph.D. Fifth Edition. Compiled and edited by JOSEPH LE ROY HAYDEN. London: Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.]

Methods of Measuring Temperatures. By EZER GRIFFITHS, D.Sc. With an introduction by Principal E. H. GRIFFITHS, F.R.S. London: Charles Griffin and Co., Limited. [Price 8*s.* 6*d.* net.]

A Manual of Motor Mechanics and High Efficiency Tuning. Dealing with the Functional Working of the Internal-Combustion Engine. By L. MANTEL. Third Edition. London: Temple Press, Limited. [Price 2*s.* 6*d.* net.]

Sulphuric Acid Handbook. By THOMAS J. SULLIVAN. London: Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.]

Il trattamento termico preliminare degli acciai dolci e semi-duri, per Costruzioni Meccaniche. By DOTT. FEDERICO GIOLITTI. Milan: Ulrico Hoepli. [Price 28 lire.]

The Hardening of Steel in Theory and Practice. By FRIDOLIN REISER. Translated from the German of the third and enlarged Edition. Second revised English Edition. London: Scott, Greenwood and Son. [Price 6*s.* net.]

Tables of Safe Loads on Steel Pillars complying with the Requirements of the London County Council (General Powers) Act, 1909. By EWART S. ANDREWS, B.Sc.(Eng.) and W. CYRIL COCKING, M.C.I., M.J.Inst.E. Vol. I. *Plated Single I-Beams.* London: James Selwyn and Co., Limited. [Price 6*s.* net.]

A Primer of Engineering Science. By EWART S. ANDREWS, B.Sc.(Eng.). Part I. *First Steps in Applied Mechanics.* Part II. *First Steps in Heat and Heat Engines.* London: James Selwyn and Co. [Price 3*s.* 9*d.* net.]

Carburation in Theory and Practice, including a Criticism of Carburettor Development. By ROBERT W. A. BREWER. Second Edition, revised and enlarged. London: Crosby Lockwood and Son. [Price 12*s.* 6*d.* net.]

Full Report of the General Discussion on "Pyrometers and Pyrometry," held by the Faraday Society on November 7, 1917. London: The Faraday Society, 82, Victoria-street, S.W. 1. [Price 12*s.* 6*d.* in paper covers and 13*s.* 6*d.* in limp covers, both post free.]

"*The Electrician*" *Electrical Trades Directory and Handbook for 1918.* London: Benn Brothers, Limited. [Price 15*s.* net.]

"*The Electrician*" *Annual Tables of Electricity Undertakings of the United Kingdom, the Colonies and Foreign Countries.* London: Benn Brothers, Limited. [Price 5*s.* net.]

From War to Work. By SAMUEL TURNER. London: Nisbet and Co., Limited. [Price 1*s.* 6*d.* net.]

SPITZBERGEN COAL.—The Norwegian Coalfields Company, Spitzbergen, reports that the installations will be ready this summer, so that regular working can be undertaken for the financial year 1918–19, with a substantial quantity ready for shipment during the summer, 1919. There have been great difficulties in connection with securing the necessary materials and tonnage, but these difficulties have now been overcome. The Board was authorised to increase the company's capital by 1,000,000 kroner.

TESTING SCIENTIFIC GLASSWARE.—The authorities of the National Physical Laboratory, after consultation with the Ministry of Munitions and the Department of Scientific and Industrial Research, and in conjunction with the British Chemical Ware Association and the British Laboratory Ware Association, have made arrangements for the testing at the Laboratory, on a much more comprehensive scale than hitherto, of scientific glassware, &c. The character of the tests which can be carried out, together with particulars of the fees charged, and instructions as to the conditions to be fulfilled when sending articles for testing, are given in circulars which can be obtained on application to the Director of the National Physical Laboratory, Teddington.

ATOMIC HEATS OF TUNGSTEN AND CARBON AT INCANDESCENCE.—It has been deduced from the quantum theory that the atomic heat of a solid at constant volume should increase with rising temperature, but not exceed the upper limit of 5.95 calories per gram-atom degree. Several determinations have, however, given higher values even at the moderately-high temperatures of 700 or 800 deg. C. Tungsten is one of these substances and was for this and other reasons chosen for exact determinations made at the Nela Research Laboratories by A. G. Worthing (*Journal Franklin Institute*, May, 1918, pages 707 to 708) with filaments mounted in evacuated bulbs. When a filament of mass m is uniformly heated to the temperature T by a current of intensity I and volts V, the rate of the energy supply is equal to the sum of the rates of radiation and of storing up energy in the filament, and this should hold both for heating and cooling; hence $IV = f(T) + C_p\, m.d\, T/d\, t$, where t is the time and C p the specific heat at constant pressure. Introducing the resistance R, the formula becomes $IV = F(R) + C_p\, m.d\, T.\, d\, R/d\, R.\, d\, t$, assuming that during changes of temperatures both the T and the radiation rate are single-valued functions of R. In this case of tungsten, the values of the atomic heat deduced from observations during heating and cooling did not quite agree; that seems to suggest that the assumption made as to R is not justified, a point further to be investigated. In the experiments I and V are determined as functions of t for certain definite temperature changes, with the aid of a pendulum switch and a potentiometer. On the whole the tungsten experiments show a straight-line increase of the atomic heat with rising temperature, but the values observed, 6.25 cal. at 1,200 deg. C absolute and 7.35 cal. at 2,400 deg. are considerably in excess of the supposed limit. For the experiments with carbon the same high accuracy is not claimed; the results obtained, 5.35 calories at 1,200 deg., and 6.05 calories at 2,000 degrees absolute, both at constant pressure, would, reduced to constant volume, fairly agree with the theoretical limit of 5.95 calories, and they are also in agreement with the previous values for diamond and for graphite found by Weber at ordinary temperature, and by Magnus at higher temperatures.

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting of the Physical Society of London, held on June 28, 1918, at the Imperial College of Science, Professor C. H. Lees, F.R.S., president, in the chair, a paper, entitled "A New Method of Measuring Alternating Currents and Electric Oscillations," was read by Mr. L. Williams. The method consists of the application of the Crookes and Osborne Reynolds radiometers to the measurement of the R.M.S. values of electric currents. Two types of apparatus are described. In the first of these the heat generated by the passage of the current through a nichrome resistance causes the deflection of a light mica vane attached to the extremity of a suspended beam. In the second type the deflection of a fine fibre is employed. Tables and curves are given connecting the indications of the instruments with the current and with the degree of evacuation.

Mr. G. D. West said that in his paper "*On the Measurement of the Pressure of Light*" by the deflection of a thin metallic strip he had called attention to certain disturbances due to gas action. He treated them at that time as sources of error, but had since been engaged on their investigation. He could not go into his results then, but would just like to say that some of the effects shown by the author were not wholly explicable by the Crookes radiometer effect. He would also like to point out that Knudsen had studied the deflection of strips placed close to an electric heater. There were possibilities of the useful application of some of these effects when they were properly understood. At present, however, there was considerable uncertainty in connection with some of them.

Dr. Sumpner thought the instrument described by Mr. Williams was likely to prove a valuable one. Comparatively little information was given concerning the heaters, so it was difficult to judge of their suitability for the currents employed in wireless telegraphic work, which were very much smaller than those mentioned. There was the danger that if the resistance had to be made too high the instrument would alter the magnitude of the current it had to measure.

Professor Howe said that one of the difficulties in measuring high-frequency oscillations was the effect of electrostatic forces between the heater and the thing heated. It appeared to him that this type of instrument was particularly liable to this source of disturbance. An obvious way to overcome this was to put a dummy heater on the other side of the vane or fibre and put it in electrical connection with the heater. He thought that in its present form the instrument could not be very convenient in use.

Dr. D. Owen said he was not certain that the difficulties inherent in the measurement of minute forces had all been surmounted. From Table I it would appear that they had, as in this case the deflections were stated to be accurately proportional to C^2. This law was not, however, followed in Table III, the deflections being all smaller than they should be, despite the fact that a platinum heater was used in this case, which would lead one to expect too high readings. He observed that the author connected the heater to earth, and gathered from this that electrostatic disturbances had been noticed. It was not easy to apply this method of elimination of these effects in the case of high-frequency oscillations.

Dr. W. Eccles said that some years ago he had built a little apparatus which would detect a microampere. The heater was a short glass fibre platinised. It was mounted about 2 mm. below the extremity of a light horizontal fibre of quartz, which constituted the beam of a delicate microbalance. The effect was best at atmospheric pressure, and he had always attributed it to convection currents; but it seemed that there might be many other factors entering into it. The heater was of about 1,000 ohms, so that the value of the watts per microampere consumed was 10^{-3}. He also made another type, in which a light vane was mounted at the end of the beam. This was several times as sensitive as the first. He had described these in one of his papers at the time.

Professor Lees asked how the pressure was maintained sufficiently steady, as the sensitivity appeared to vary considerably with the pressure.

Mr. Williams, in reply, said he had had no difficulty with pressure. The change of sensitivity with pressure was small near the top of the curve, at which he usually worked. This question did not, of course, arise at all when employing the Null method. He had not seen any of Knudsen's work when he started these experiments, and originally intended to use the instrument as a manometer, as it was suitable for measuring very small changes of pressure due to leakage or transpiration through substances. He subsequently found, however, that Knudsen's work already covered this ground. With regard to Dr. Sumpner's remarks on the magnitude of the current, it had to be borne in mind that the instrument described was an experimental one, and could be very much improved by reducing the inertia of the suspended system and using a much finer suspension. With regard to the square law, the graph in the paper applied to the first type of instrument only; he thought Dr. Owen's remarks applied to observations made with the other type. As regards electrostatic disturbances he thought at first he detected effects of this kind, but found they were unaffected by the proximity of radium. He had subsequently found them to be mostly due to other causes.

"*A Demonstration of Coupled Vibrations*" was given by Professor E. H. Barton, F.R.S., and Miss H. M. Browning.

The apparatus shown consisted of a pair of pendulums, each of which was suspended from the mid point of a sagging string, the direction of which was transverse to the direction of oscillation of the pendulums. The two sagging strings were connected by a light wooden rod at the points from which the bobs were suspended. Each bob consisted of a metal funnel, from the apex of which a fine stream of sand fell during an experiment. A horizontal board could be moved slowly on rails just below the oscillating bobs, and the fine sand falling on this gave curves showing their motion. When one bob is set in oscillation the other being initially at rest the latter, as is well known, starts to vibrate with gradually increasing amplitude until the first bob has been brought to a standstill, when the process is reversed. From an examination of the equations of motion it is found that the amount of sag in the transverse strings governs the degree of "coupling" of the oscillators, and by varying this and also the relative mass and periods of the pendulums, curves can be obtained illustrating all the phenomena of coupled electrical oscillations. By stopping one of the bobs when it has just been reduced to rest, thereby preventing the energy from being reabsorbed by it, the conditions of the quenched spark can be imitated.

Mr. B. W. Clack (communicated remarks) would like to call the attention of Fellows to a pen for recording traces similar to those shown by Professor Barton, which does not seem to be so well known as it deserves. The writing point of this pen is a very fine sable hair or camel hair brush, the bristles of which fill up and project outwards through the opening of a short length of glass tubing, suitably drawn out at one end, and which acts as a reservoir for the ink. The advantages of this pen for the purpose under consideration are three: (1) The point of the brush when wet with the ink is exceedingly fine, but the thickness of the line drawn can be increased at will by changing the pressure of the brush on the paper. (2) The point is quite flexible, and will write equally well in all directions. (3) There is nothing to get clogged up in the writing point, and the pen will do its work for hours without any attention. The writer does not know who is the originator of this method, but he has used it for many years with perfectly satisfactory results, and if such a recording device could be employed by Professor Barton it would enable him to materially reduce the size of his apparatus, as 100 waves or more can easily be drawn in the length of a postcard.

At the close of the meeting the president referred to the retirement of Mr. R. Chapman, who had acted as lecture demonstrator at their meetings for longer than most of them could remember. He expressed the Society's appreciation of his past services and also their good wishes for the future.

EXHIBITION OF NAVAL PHOTOGRAPHS.—Interest in the work of the Navy has never been lacking, but the exhibition of coloured photographs now being shown to the public at the Princes Galleries, Piccadilly, under the direction of the Ministry of Information, will enable the "stay-at-homes" justly to appreciate the multifarious duties of the senior service which are carried out with such thoroughness and under so many difficulties. Pictures from the shipbuilding yards and the gunshops, views from aeroplanes above the water, from ships on the water and on vessels under the water taken in many parts of the world form a collection at once unique, instructive and certain to stimulate confidence in the nation's "sure shield."

THE INDUSTRIAL RECONSTRUCTION COUNCIL.—An important series of lectures is announced by the Industrial Reconstruction Council for the autumn and winter. The first of these will be given by the President of the Board of Trade on Wednesday, October 2, Mr. G. N. Barnes, M.P., occupying the chair. Other lectures will follow at fortnightly intervals, the second being delivered by the Minister of Reconstruction under the chairmanship of the Lord Mayor. Mr. W. L. Hichens, Sir Arthur Steel-Maitland, Bart., M.P., Mr. Ernest J. P. Benn, and Sir William S. McCormick, will carry the series up to Christmas, the chair being occupied by Sir Wilfrid Stokes, Lord Burnham, Mr. J. H. Whitley, M.P., and the Marquess of Salisbury. The lectures will be held at the Saddlers' Hall, Cheapside, at 4.30 p.m. A full prospectus of the series can be obtained from the Secretary, I.R.C., 2 and 4, Tudor-street, E.C. 4.

ACID-RESISTING FERRO-SILICONS.—The publication, by Camille Matignon, in the *Comptes Rendus* of May 21, 1918, of the results of some corrosion tests of his, comes very late. He conducted the tests in 1913 with the alloys then obtainable; the analyses and corrosion values are interesting, however. His alloys were various ferro-silicons, containing between 13 per cent. and 17 per cent. of silicon, nearly 1 per cent. of manganese and, in addition to the usual phosphorus and sulphur, only the constituent we mention: the métillure of Adolphe Zouve contained 2·5 per cent. of aluminium; one of the two elianites (an Italian product) contained 2·2 per cent. of nickel and seemed to be less corrodible owing to this constituent; the other ferro-silicons were ironac and duriron, which we have noticed on other occasions. Matignon further tested a German ferro-boron (with 70 per cent. of iron, 15·4 per cent. of boron, 4·9 per cent. of silicon, and 3·3 per cent. of manganese), and Borchers metal, a nickel-chrome (64·6 per cent. of Ni, 32·3 per cent. Cr., 0·5 per cent. silver, 1·8 per cent. molybdenum). The corrosion tests were made in boiling nitric acid and in boiling mixtures of acetic acid and butyric acids, concentrated and diluted. The ferro-boron was easily attacked; the Borchers metal differed from the other alloys by resisting diluted acids better than concentrated acids, but was not otherwise superior to them; the best métillure was a very homogeneous alloy. None of the alloys resisted hydrochloric acid; there is no mention of sulphuric acid. Some of the tests were continued for 360 hours.

BRITISH MACHINERY FOR THE MALAY PENINSULA.

WITH engineering works concentrating on the production of war material, it is not to be wondered at that the exports of machinery from the United Kingdom to overseas possessions should show considerable contraction during the past three or four years. Nevertheless, the needs of the Colonies have had to be considered, especially such territory as the Malay Peninsula, where rapid development was in progress when hostilities broke out. Taking three principal sections of the machinery statistics, and excluding sewing machines (largely in the hands of British manufacturers and showing only slight fluctuations), the following interesting comparisons can be made from the official returns of imports into the Straits Settlements, through the port of which most of the trade of British Malaya is conducted:

—	1913.	1914.	1915.	1916.
	£	£	£	£
Electrical	74,095	50,898	39,890	44,203
Engines and boilers ..	129,108	93,349	59,622	112,902
Other, unenumerated ..	169,952	139,635	112,251	162,885
Total	373,155	282,882	211,563	319,990

The comparison of values only may be somewhat misleading as to the total volume of trade, but after allowing for enhanced values during war years, it is satisfactory to be able to record that the 1916 statistics show a marked improvement on those of the previous year. Before the war, Germany ranked second, but was a long way behind the United Kingdom in the supply of electrical machinery. In the supply of engines and boilers, both Belgium and the United States came in front of Germany; while as regards unclassified machinery the United States took precedence of Germany, both being considerably outdistanced by the United Kingdom. Appended details in regard to engines and boilers are taken from the official returns; attention may be directed to the extraordinary fluctuation in the imports from Australia and to the appearance, for the first time, of Sweden in the statistics for 1916:—

Engines, Boilers and Parts.

—	1913.	1914.	1915.	1916.
	£	£	£	£
United Kingdom	107,928	76,221	50,622	68,418
Belgium	7,126	207	—	—
United States	4,193	1,936	911	1,988
Germany	2,810	991	—	—
Netherlands	2,755	4,585	571	1,196
Federated Malay States ..	1,708	556	211	1,986
Hongkong	583	50	1,942	1,512
Australia	87	7,000	3,850	24
Japan	60	35	140	204
Sweden	—	—	—	11,655

A portion of the imported machinery is re-exported to British North Borneo, Siam and Netherlands, India. The total value of machinery imported into the Federated Malay States in 1916 amounted to 222,937*l.*, against 157,237*l.* in 1915.

COUNTY OF LONDON ROYAL ENGINEER VOLUNTEERS.—Recruits are wanted for the Royal Engineer Volunteers—known as the London Army Troops Companies—the only volunteer field engineer corps in the London area. In addition to ordinary infantry drill and musketry, the work of the corps includes many forms of field engineering. Pontoon bridging, trestle bridging, barrel bridging, demolitions, entrenching, revetments, obstacles, knots and lashings, the construction of field kitchens and incinerators are some of the conspicuous items in the scheme of training. Technical knowledge is an advantage, but not a necessity. Mechanical and building tradesmen are specially wanted. The headquarters of the corps are conveniently situated at Balderton-street, Oxford-street, W., opposite Selfridge's. Drills are held there and lectures given on various aspects of field engineering. Practical work in bridging, &c., is carried out on the banks of the Mole at Esher, during Sunday parades held about twice a month and on other special occasions. Uniforms and equipment are provided free to recruits who are passed as efficient. The subscription is 5*s.* per quarter.

THE LATE PROFESSOR F. P. TREADWELL.—Professor Frederick P. Treadwell, of the Federal Technical High School at Zürich, who died suddenly of heart failure in the last week of June, was known all over the scientific world as an authority on analytical chemistry and author of the most popular text-book on the subject. Born in February, 1857, at Portsmouth, New Hampshire, as son of a Captain in the United States Navy, he was brought over to Switzerland, together with a younger brother, by his father to learn French, and later taken to Germany to complete his education. Having studied chemistry under Bunsen at Heidelberg and later at Göttingen, he came back to Switzerland as assistant to Victor Meyer at the High School, then known as the Zürich Polytechnicum, and settled at Zürich. He was appointed to the chair of analytical chemistry in 1894. The first edition of his "Short Treatise of Analytical Chemistry" appeared in 1901. The book had quite an exceptional success, and was translated into all languages; the ninth edition of the first volume, a book of 500 pages, was ready for the binders when he died; the seventh edition of the second volume, 750 pages, had been brought out in the end of 1916. Treadwell was widely esteemed as a man of learning and as a teacher.

INKSTAND FOR INKS OF DIFFERENT COLOURS.

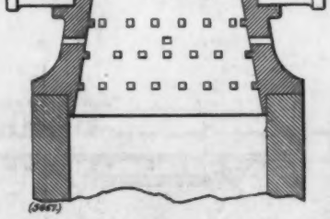
ARCHITECTS, draughtsmen, map makers and others often have to use eight or more different colour inks in making complicated plans, drawings or maps, and it is of common occurrence, with the means usually available, to dip the pen into the wrong ink and so to draw a wrongly-coloured line, entailing a waste of time and of material. Major Frank B. Gilbreth, E.R.C., United States Army, of Providence, R.I., the

well-known efficiency expert and engineer, has overcome this difficulty simply and easily by devising a special stand to hold both the inks and their separate pens, as shown in our illustration herewith. Each pen stands upright in a hole in front of the ink bottle to which it appertains. When a black line has to be drawn, the worker takes out the black ink pen and thus clears the way to the black ink alone; there is no access to any other ink. Our illustration was communicated to us by Mr. James F. Butterworth, 24, Linden-gardens, London, W.

FEEDER HEAD FOR INGOT MOULDS.

THE annexed illustration shows a section of the Parks improved feeder head, the novel feature of which is the flange or lip on the bottom of the head, which projects into, and directly engages with the inside of the mould, thus making the mould and head into practically one complete whole. This type of head can be fitted to either a square, rectangular, or octagonal mould, and the particular advantages claimed for it are as follow:—

1. When casting, it can be filled to the brim without



sign of "lifting," enabling a larger and longer head, free from pipe, to be obtained on the ingot, the whole being contained in the enlarged head.

2. It ensures an absence of "pulling" and the consequent cracking of the ingot, as it is impossible for the molten steel to get over the top of the mould inside the head on account of the flange, which allows the cooling ingot to shrink down into the mould without obstruction.

3. When "setting," the flange ensures that the head is placed in its true position with regard to the mould.

A considerable number of these heads are now in use in several steel works, and further particulars of them can be obtained from Mr. J. M. Moorwood, Eagle Foundry, Stevenson-road, Attercliffe, Sheffield.

PERSONAL.—Messrs. Samuel Denison and Son, Limited, Hunslet Foundry, Leeds, makers of weighing machines and testing apparatus, have opened offices in London, at 28, Victoria-street, Westminster, S.W. 1.

THE DETERMINATION OF COBALT AND NICKEL IN COBALT STEEL.*

By W. R. SCHOELLER, Ph.D., and A. R. POWELL, London.

THIS paper is the second on the subject of a rapid process for determining cobalt and nickel in ores and alloys. The first communication was published in the *Analyst* (1917, vol. xlii, page 189). The reaction on which our process is based consists in the precipitation of hexammine cobaltous and hexammine nickelous iodides by means of potassium iodide in strongly ammoniacal solution, the precipitation of the trivalent metals by the ammonia being prevented by the addition of tartaric acid. Iron, which in the usual methods of assay is removed by precipitation and causes trouble by occluding some of the cobalt and nickel, is thus removed in a soluble form.

In applying this procedure to cobalt steel, it was at once found that the large amount of tartaric acid required to keep up the iron and chromium (10 grammes for 1 gramme of steel) retarded the complete precipitation of the cobalt sufficiently to render the process useless. An attempt was therefore made to remove the bulk of the iron by precipitation, and then complete the separation by the iodide process. Such a manipulation would still be preferable to the removal of the iron by one of the usual methods (*e.g.*, as basic acetate).

The elimination of the bulk of the iron was satisfactorily accomplished by means of sodium carbonate, using thiocyanate as an external indicator. The filtrate was then evaporated to dryness with nitric acid, taken up with 2 grammes to 3 grammes of tartaric acid, made strongly ammoniacal, and precipitated with potassium iodide (Method I).

The process now proved much more satisfactory than in its original form, and the figures obtained were mostly in close agreement; yet, on continuous testing, the results were rather erratic, the iodide precipitate sometimes crystallising out slowly instead of forming instantaneously on adding the potassium iodide. After much investigation we came to the conclusion that cobalt is precipitated less readily from tartrate solutions than nickel; if the latter is present in sufficient proportion, it induces more rapid precipitation of the cobalt; if not, a minimum concentration of tartrates should be aimed at, and this in turn would depend on the quantity of trivalent metals, the precipitation of which must be prevented. Now the addition of 2 grammes to 3 grammes of tartaric acid in the above procedure was necessitated by the presence of chromium. The latter is precipitated by sodium carbonate only after the whole of the iron has been thrown down, and to attempt its removal at this stage would involve the risk of precipitating some of the cobalt, as no convenient spot test is available for detecting soluble chromium salts in a solution containing a highly-coloured iron compound.

The method was therefore further modified by eliminating the bulk of the chromium in the following manner. The filtrate from the iron precipitate was precipitated, hot, with caustic soda and bromine. The precipitate consisting of the higher oxides of cobalt, nickel and manganese, together with a little ferric hydroxide and a trace of chromium, was filtered from the solution containing sodium chromate, dissolved in hydrochloric acid, the solution evaporated to dryness, the residue taken up with a little tartaric acid, and precipitated with ammonia and iodide (Method II). The results then became concordant.

The procedure in its improved form would seem somewhat complicated, but Method II is actually shorter than Method I in that it obviates the evaporation to dryness of the filtrate from the iron precipitate. It is considerably quicker than the basic acetate process, apart from the fact that the latter is ineffectual in presence of much chromium. For the further treatment of the iodide precipitate, several methods may be used. After dissolving the precipitate in hydrochloric acid, the cobalt may be thrown down by nitroso-β-naphthol, or the nickel by dimethyl-glyoxime. In this investigation the authors have made use of their previously published method for the separate volumetric estimation of cobalt and nickel.† Full directions for carrying out the process will be given below. As regards the time required for the determination, several assays can be completed in about 3 hours to 4 hours from the time the steel has been obtained in solution. The attack is usually rather protracted, several hours' boiling with aqua regia being required.

The material used in this investigation was kindly supplied by Mr. C. O. Bannister, to whom the results given in the table were submitted. Mr. Bannister is satisfied that these figures closely check those obtained by him by analysis. Sample H was assayed according to Method I, and the supply of material was exhausted before Method II was adopted. The latter was used on samples I to K:—

Description of the Method.—Two grammes of drillings are weighed into a flask and treated with 30 c.c. each of strong hydrochloric and nitric acids. The assay is heated gradually at first, then boiled gently for 4 hours to 6 hours, and evaporated substantially to dryness over a free flame; 2 c.c. of sulphuric acid (1 : 1), a little hydrochloric acid, and 25 c.c. of water are added, and solution brought about by warming. The addition of the prescribed amount of sulphuric acid is essential for success, as it produces a pale brown pulverulent iron precipitate which is easily filtered off.

The cooled solution is diluted to 50 c.c. and precipitated with 20 per cent. sodium carbonate solution added from a burette. When the iron begins to come down, a drop is withdrawn between the additions of carbonate and brought in contact with a drop of 10 per cent. thiocyanate solution in a flat porcelain dish used as a spot plate. When the red coloration grows faint and becomes masked by the rust-brown precipitate, the spot tests are returned to the assay and the latter transferred to a graduated 200 c.c. flask. The volume is made up, the solution filtered through a pleated 12·5 cm. filter, and 100 c.c. pipetted into a 300-c.c. beaker. The liquor is brought to a boil with 1 c.c. to 2 c.c. of nitric acid and treated with 25 c.c. of bromine water and an excess of freshly-made caustic soda. After boiling for a minute or so, the black precipitate is filtered off on loose paper (Whatman, No. 4, 9 cm.) and washed with boiling water. It contains all the cobalt and nickel, together with small quantities of iron, chromium and manganese, and its subsequent treatment does not differ from that previously published, except that a colorimetric manganese determination is necessary in the titrated cobalt solution.

Experiment.	Sample.	Cobalt per Cent.	Nickel per Cent.	Cobalt + Nickel per Cent.
115D	H	3·51	0·68	4·19
108E		3·54	0·63	4·17
108C		3·58	0·65	4·23
116A	I	3·21	0·55	3·76
116B		3·19	0·55	3·74
118A		3·27	0·41	3·68
119A	J	3·85	0·57	4·42
119B		3·87	0·57	4·44
122A		3·84	0·55	4·39
123A	K	3·62	0·62	4·24
124A		3·64	0·55	4·19
124B		3·67	0·55	4·22

The precipitate is rinsed back into the beaker, dissolved in a little hydrochloric acid poured over the filter, the solution transferred to a flask, and evaporated almost to dryness over a free flame. It is again evaporated with 2 c.c. of strong nitric acid to destroy the bulk of the chlorides. A cold saturated solution of 1 gramme tartaric acid is now added, then 50 c.c. to 60 c.c. of strong ammonia (0·88 specific gravity), followed immediately by a cold saturated solution of 4 grammes potassium iodide. A pale pink crystalline precipitate is at once thrown down. After settling for 15 minutes, it is filtered off on a loose 9-c.m. filter, and washed with ammoniacal iodide solution (strong ammonia 200, water 50 c.c., potassium iodide 10 grammes) from a wash-bottle fitted with a Bunsen valve.

The iodide precipitate (containing only cobalt and nickel with a little manganese) is dissolved in 10 c.c. of hydrochloric acid (1 : 1) and a little sodium sulphite poured through the filter into a 300-c.c. beaker; the washing is done with hot water; 5 c.c. of 25 per cent. ammonium phosphate solution* are added, the liquor heated to boiling, and treated with ammonia (1 : 1), added finally drop by drop with continual stirring, until the blue amorphous precipitate at first produced becomes pink and crystalline. An excess of five drops of ammonia is then added and the assay left to stand on a steam bath for 10 minutes; a reprecipitation is unnecessary.

Cobalt Titration.—The pink precipitate of cobalt ammonium phosphate is filtered on a loose 9-cm. paper and well washed with hot water. The filter is spread against the side of the beaker, rinsed down with water followed by a few drops of the N/5 acid used in the titration and again with water to displace the acid, taking care not to use more than about 30 c.c. in all. The filter is now discarded, and the gradual addition of acid continued until the precipitate disappears. No indicator is required, for the precipitate imparts a lilac colour to the liquid, while its final disappearance can be ascertained with 0·1 c.c. In order to determine the manganese (which is precipitated with the cobalt as manganese ammonium phosphate) the above titration must be carried out with N/5 sulphuric or nitric, but not hydrochloric, acid. The titrated liquid is filtered (to free it from filter fibres) into a 100-c.c. graduated flask. 10 c.c. or 20 c.c. are pipetted off, boiled with persulphate and silver nitrate in the usual manner, and the colour matched against that of a standard solution containing 0·072 gramme of potassium permanganate per 500 c.c. (1 c.c. = 0·05 milligramme manganese); 1 milligramme to 3 milligrammes of manganese are thus found. The acid consumed by the manganese ammonium phosphate (0·18 c.c. per milligramme of manganese) is subtracted from the volume found, the difference giving the cobalt (1 c.c. of N/5 acid = 0·0059 gramme of cobalt).

Nickel Titration.—The filtrate from the cobalt ammonium phosphate is cooled and titrated with a solution containing 10 grammes of sodium cyanide, 2 grammes of caustic soda, and 1 gramme of silver nitrate per litre. The quantity of nickel being very small, the assay is left to stand for a few minutes after about 1 c.c. of cyanide solution has been added, when the cloudiness due to silver iodide becomes visible. The addition of cyanide is then continued drop by drop, whilst shaking, until the liquid clears. The cyanide solution is standardised every week against pure nickel or silver.

* Paper taken as read before the Iron and Steel Institute, May 3, 1918.

† *Analyst*, 1916, vol. xli, page 124.

* The salt is dissolved in hot water tinted with methylorange, and hydrochloric acid added till the colour turns pink. Boil 5 minutes, cool and filter into stock bottle.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

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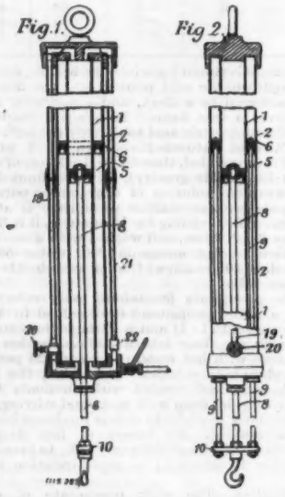
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

LIFTING AND HAULING APPLIANCES.

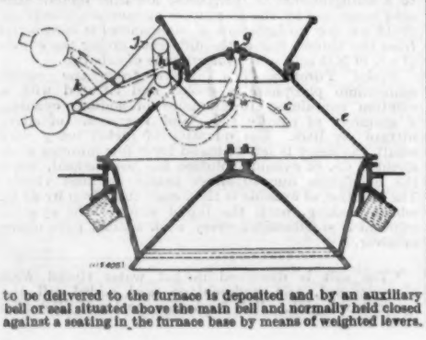
115,385. H. J. Munro, Pontardawe. Lifting or Hoisting Apparatus. (7 *Figs.*) December 12, 1917.—This invention has reference to apparatus in which the load is lifted by compressed air, and provides improvements in such apparatus whereby the load is, when raised, held suspended and is lowered independently of the means by which it was raised. The suspensory and lowering medium employed is an incompressible fluid, such as oil or water, and the combined suspensory and lowering medium comes into action automatically at any point in the lifting of the load, whether the supply of compressed air be cut off or fail. Pneumatic lifting or hoisting apparatus, in accordance with this invention, comprises the combination with a lifting or hoisting cylinder 2 and piston 6 having means, such as valve-controlled pipe 24, for the introduction of an operating fluid, such as steam or compressed air, and a suspensory and lowering cylinder 1 and piston 5, said cylinder being filled on both sides of the piston with an incompressible fluid, such as water or oil, and having two



valve-controlled conduits 19, 21 connecting the two sides of the piston, the valve 22 in the conduit 21 being an automatic non-return valve and the valve 20 in the conduit 19 being operable at will, of means connecting the two pistons so that they move together, such means comprising piston rods 8, 9 connected by a cross-piece 10, the arrangement being such that when the lifting piston 6 is acted on pneumatically to raise the load, the suspensory and lowering piston 5 moves therewith and oil is forced through the connection 21 into the suspensory and lowering cylinder 1 below its piston 5, and is there retained to act as a suspensory medium until the valve 20 is opened, whereupon the oil passes back to whence it came and the load is lowered. Preferably, the cylinders are arranged the one within the other concentrically, one piston comprising a ring moving in the annular space between the inner and outer cylinders. Further, one of the valved conduits connecting the two sides of the piston in the suspensory and lowering cylinder may be formed through the piston. (*Accepted May* 15, 1918.)

MINING, METALLURGY AND METAL WORKING.

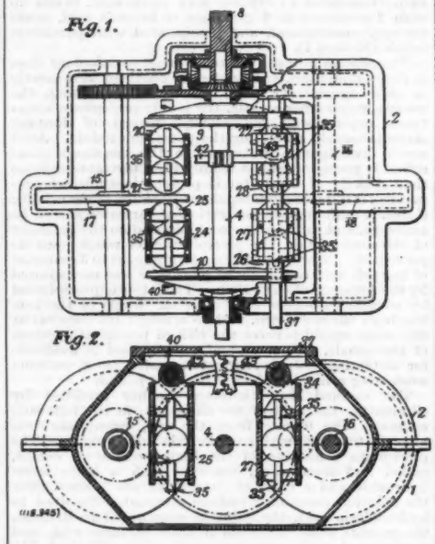
115,405. A. Sahlin, London. Blast Furnaces. (1 *Fig.*) March 20, 1918.—This invention relates to blast furnaces wherein the mouth of the furnace is closed by a bell upon which the charge



to be delivered to the furnace is deposited and by an auxiliary bell or seal situated above the main bell and normally held closed against a seating in the furnace base by means of weighted levers. The invention relates more particularly to this auxiliary bell or seal which, according to this invention, is supported by means of a single weighted lever *f*, the movement of which is so controlled or guided that the bell when depressed by the weight of the furnace charge or raised by the weighted lever, moves in a vertical line. The auxiliary bell *c* which is of the usual domed or hemispherical shape, is supported by a single lever *f*, the inner arm of which is bent to clear the edge of the bell with which the end of the lever is correlated by a ball and socket joint *g*. The lever passes through a slot in the furnace top *e* and is fulcrummed on a hanging link *h* pivoted on a fixed bracket *j*, and the outer arm of the lever is weighted and is connected by means of a pivoted link *k* with the bracket *j*. Instead of using the link *k* the movement of the lever could be guided or controlled by means of a pin projecting from the lever into a suitably curved slot in a fixed vertical plate, or any other equivalent guiding means could be employed whereby the inner end of the lever and therefore the bell *c* would be caused to move in a vertical or substantially vertical line when the bell is depressed by the weight of the furnace charge to the open position (shown dotted in the drawing) or raised by the weight of the outer arm of the lever to the closed position. (*Accepted May* 15, 1918.)

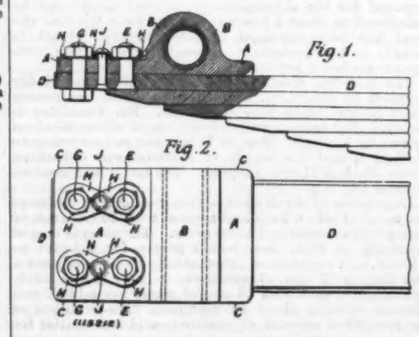
MOTOR ROAD VEHICLES.

115,345. H. C. Ford, New York, U.S.A. Variable Speed Gear. (2 *Figs.*) July 30, 1917.—This invention relates to mechanism of the type in which the motion of a moving body is transmitted to a second body by means of a ball interposed between the driving and driven bodies, provision being made for moving the ball towards or away from the centres of rotation of said driving and driven bodies whereby the speed of the driven body may be varied. The transmission is enclosed in a casing comprising two sections 1, 2. One end of a main driving shaft 4 is mounted in ball bearings and its other end is rotatably supported within a recess in a driver shaft 8. Discs 9, 10, are mounted on the shaft 4. Auxiliary driving shafts 15, 16, carry discs 17, 18,



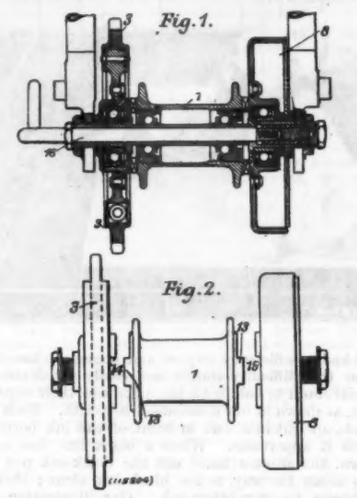
which rotate therewith. A pair of balls, mounted one upon the other, is interposed between each pair of discs, the balls being designated 20, 21, 22, 23, 24, 25, 26 and 27. Cages surround the balls and hold them in position. Each cage is secured at one end to a block 34. Mounted in the cages are rollers 35. Two of the cages are mounted upon a shaft 37 and the other two cages are mounted upon a shaft 40. These two shafts are connected together by sector gears 42, 43, so that the cages are moved simultaneously to maintain the shafts 15, 16, rotating at the same speed, but varying the speed of these shafts relative to that of the shaft 4. (*Accepted May* 15, 1918.)

115,212. Albion Motor Car Company, Limited, and T. B. Murray, Scotstoun. Laminated Springs. (3 *Figs.*) January 12, 1918.—According to the invention, the shackle eye is formed in a lug which is attached by any convenient means to the leaf end. Preferably, the lug, which is of such form that it leaves the end of the leaf free to be supported by the extended



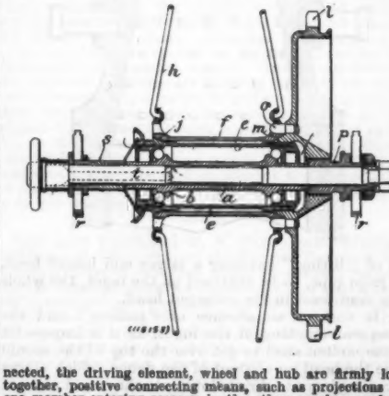
ends of the leaves adjacent to it, is of channel section on that face which is adjacent to the leaf, so that the leaf fits within it, and is so held against lateral movement, and, preferably, the lug is anchored to the leaf between the eye and the end of the latter. The lug A, provided with a pierced eye boss B, has dependent side flanges C, so that its under-side forms a channel in which there snugly fits the topmost leaf D of the spring. The lug is anchored to the leaf end by bolts E countersunk in the leaf and by bolts G passing through lug and leaf. The nuts for the bolts and studs are locked by plates H, which are secured in place by rivets J. Thus, the top leaf D can be extended, as shown, with normal curvature considerably beyond the centre of the eye, and the second and third leaves of the spring, and more if need be, may be similarly extended to support the main leaf D, giving ample support to the main leaf D, which, in the ordinary method of construction, is very apt to fracture at or near the eye. (*Accepted May* 8, 1918.)

115,204. W. F. Lechmere and The James Cycle Company, Limited, Greet, *juxta* Birmingham. Wheels. (3 *Figs.*) December 7, 1917.—The invention refers to that class of interchangeable wheel which is designed for use in conjunction with a fork mounting. According to this invention, there is employed, in combination, a sprocket wheel 3 rotatably mounted upon a sleeve secured to the frame, a brake drum 8 rotatably mounted upon another sleeve secured to the opposite side of the frame, a hub 1 disposed between the sprocket wheel and the brake drum,



mutually engaging projections and recesses on the outer faces of the hub and the inner faces of the sprocket wheel and brake drum, and a detachable non-rotatable spindle passing through the hub and sleeves. Each end of the hub is provided with a diametrically-disposed projection 13, which is adapted to engage with a correspondingly-shaped recess 14 in the sprocket and a similar recess 15 in the brake drum. The hub is secured in position by means of a detachable spindle 16. (*Accepted May* 8, 1918.)

115,153. W. Comery, Mapperley Park, Nottingham, and The Raleigh Cycle Company, Limited, Lenton, Nottingham. Wheels. (5 *Figs.*) July 24, 1917.—This invention relates to wheel, primarily intended for motor cycles. According to the invention, the hub proper *e* is formed as a separate fitting, mounted upon a hollow sleeve-like spindle *a*, the usual ball or roller bearings being interposed. The wheel is provided with a tubular, shell-like centre *f*, which is flanged on the exterior to receive the spokes *h*, and is adapted to fit on to the hub *e*, an inclined projecting rim *j* on the latter engaging one end of the wheel centre. The driving element, which may be a gear wheel such as a sprocket wheel *b*, is centred on a member *p* adjustably secured to the frame, and is provided with an inclined surface *m* adapted to engage with the adjacent end of the wheel centre *f*, means such as inter-engaging screw-threads being provided on the driving element *l* and hub proper *e* to secure the same together with the wheel centre wedged between the two. When so con-



nected, the driving element, wheel and hub are firmly locked together, positive connecting means, such as projections *o* on one member entering recesses in the other member, preferably being provided between the two former. The member *p* secured to the frame is bored to correspond with the hub spindle and a short sleeve or distance piece *s* correspondingly bored is adapted to complete the distance between the two sides of the frame *r*, a removable bolt *t* being threaded through the three members and the side frames to secure them together, with the wheel in the correct position, in said frame. The bolt may be bored and one end enlarged to form a lubricant reservoir, transverse holes being formed in the bolt and hub spindle to allow lubricant to be forced into the hub. When it is desired to remove the wheel, the through bolt *b* is withdrawn, the short tubular distance piece *s* removed, and the hub *e* is then disconnected from the driving element *l* which is left centred on the member *p* attached to the frame, the wheel and hub being removed bodily, and then slid apart. (*Accepted May* 8, 1918.)